Enhancing students mathematical creative skill and resilience by using problem posing approach

H Hendriana¹, U Sumarmo¹, C Carli¹, M G Ristiana¹,², and H D Putra¹

¹ Mathematics Department, Institut Keguruan dan Ilmu Pendidikan Siliwangi, Jalan Terusan Jenderal Sudirman, Cimahi, Indonesia
² Postgraduate Student of Mathematics Education, Universitas Pendidikan Indonesia, Jalan Setiabudi No. 229, Bandung, Indonesia

Abstract. This paper reports the findings of a pre and post test and control group design of quasi experiment having a goal to analyze the role of problem posing approach (PPA) on student’s mathematical creative skill (MCS) and student’s mathematical resilience (MR). The study involved 70 eleventh-grade students in Bandung Indonesia, an essay MCS test, a MR scale, and a student’s perception toward PPA scale. The study found, on MCS, and its N Gain, students getting treatment with PPA obtained higher grades than students taught by conventional teaching. On MCS, student of PPA class attained at medium grade level while student of conventional teaching class obtained at low grade level. Even tough on MR, study found was no different student’s grades in both teaching approaches class and the grades were at medium level. The other findings, was no association between student’s MCS and MR and students performed positive perception toward PPA.

1. Introduction
The low grade of student’s mathematical creative skill (MCS) some time was addressed caused of MCS was too difficult for high school student, or irrelevant teacher’s strategy in delivering mathematics content as if conventional teaching. There were findings supported to that statement, such as some studies reported that on MCS, students getting treatment with various innovative teaching obtained better grades than student taught by conventional teaching, and those grades were at low to fairly good level [1-4]. However, researchers believed MCS was still an essential mathematics learning outcome should be possessed and improved on high school students.

Some reasons endorsed the importance of owning MCS, among other were MCS was attached in the goal of mathematics teaching namely to improve student’s potency to become a critical, creative, logical, accurate, and innovative human (Mathematics Curriculum of Indonesia and National Council Of Teachers Of Mathematics [5]). In general MCS was essential and required life skill should be possessed by any people for comforting rapid improvement of science and technology, challenge, demand, and tight global competition [6]; People who accustomed to think creatively would be ingenious and take action fluently when he faced unpredictable situation, whereas individual who seldom performed creative thinking would realize a deadlock and be worried when confronting curious problem [7].

Creativity involved four main components namely fluency, flexibility, originality, and elaboration [8]. Then she detailed those components into some activities among other were: To provoke many ideas,
answers, problem solving, and questions; to consider a problem from different viewpoint; to think unusual, new and unique; to increase or to detail an object, idea, or solution so that it became more interesting. Considering to those aforementioned traits of MCS, researchers believed MCS was heavy, complex, and difficult High Order Thinking (HOT) mathematical task. That statement implied for executing MCS task, student should have strong mathematical soft-skill and interest in mathematics so that he would hard fight and uneasy give up in solving difficult mathematics task. One kind of that soft-skill was Mathematical Resilience (MR).

Some experts defined resilience term differently but those definitions contained similar traits namely having persistent and strong attitude, willingness and spirit on overcoming heavy challenge or pressure, and able to release from depressed condition [9]; Having self-confidence on own success through hard work, performed persistent to face difficulties, had willingness to discuss, to reflect, and to research. From those statements Sumarmo implied students who own strong MR would use mathematics for solving any unpredictable problem situation [10]. Mathematics Curriculum of Indonesia suggested that mathematics hard-skill such as MCS and mathematics soft-skill such as MR should be developed simultaneously. Teaching-learning approach which conforming to that suggestion among other was problem posing approach (PPA), which facilitated student to pose problem from given information for understanding problem and solving it.

Brown & Walter proposed two main perspectives in PPA those were accepting and challenging [11]. Then they detailed those perspectives into some steps among other were accepting phase enclosed activities: to orientate students on a contextual problem and motivate them to learn it deeply; challenging phase or What if Not (WIN) strategy contained some activities: to guide students to pose some questions related to problem situation, and try to solve it. Some studies reported advantages of PPA than conventional teaching on improving various students’ mathematics abilities [12-14]. Other studies by using various teaching approaches notified that students obtained MCS at low to fairly good grade level [15, 16]; while Abdurrohim and Murni et al. [17, 18] found students obtained MR at medium to fairly good grade level, and Aryanto et al. detected prospective teachers getting treatment with problem based learning attained N<Gain> on MR [19].

2. Method

This study was a pre-test post-test quasi-experimental design which having a goal to analyze the role of PPA on student’s MCS and MR. The study involved 70 eleventh-grade students in Bandung Indonesia, an essay MCS test, a MR scale, and a student’s perception toward PPA. The MCS test consisted of 6 items [20] as follow: reliability test was $r = 0.71$; item validity (IV) were $0.69 < VI < 0.79$; discriminant power (DP) were $0.19 < DP < 0.50$ and difficulty index (DI) were $0.31 < DI < 0.63$. The MR scale contained of 33 items with reliability scale was $r = 0.80$ and $2.22 < t_{cal} < 5.20$ ($t_{tab} = 2.02$), and the perception toward PPA scale contained of 30 items. The study analyzed the scores of pre-test, post-test, and N-gain of student’s MCS, scores post scale of MR in both teaching approaches, but only score of post-scale of perception toward PPA for students getting treatment with PPA. The statistical analysis used in this study were $t$-test, Mann-Whitney test for testing mean differences, and statistics $\chi^2$ for testing the existence of association between MCS and MR, and all testing at significance level 0.05.

3. Results and discussion

3.1. Results

Description of student’s MCS and MR were attached in Table 1 below. From Table 1, in pre-test study found was no difference of student’s MCS in both teaching approaches, and the grades were at very low level. Nevertheless, after learning process, on MCS and its gain (N<G>), students getting treatment with PPA attained better grades than the grades of students taught by conventional teaching.
Table 1. Description of students’ MCS and MR in both teaching approaches.

| Variable | Stat | Problem Posing Approach | Conventional Teaching |
|----------|------|--------------------------|-----------------------|
|          |      | Pre-test | Post-test | N Gain | n | Pre-test | Post-test | N Gain | n |
| MCS      |      |           |           |        |   |            |           |        |   |
|          | x    | 12.77     | 37.06     | .52    | 35 | 13.40     | 27.31     | .30    | 35 |
|          | %    | 21.29     | 61.76     | 1.17   |   | 22.33     | 45.52     |        |   |
| MR       |      |           |           |        |   |            |           |        |   |
|          | x    | 86.74     |           | 35     |   | 85.91     |           | 35     |   |
|          | %    | 64.73     |           |        |   | 64.12     |           |        |   |
| PPPA     |      |           |           |        |   |            |           |        |   |
|          | x    | 2964      |           | 35     |   | 70.57     |           |        |   |

Note: Ideal score of MCS: 58 Ideal score of MR: 134 Ideal score of PPPA: 4200.

However, on MR was no different students’ grades in both teaching approaches, and those grades were at medium level. Besides that, study found students’ perception on PPA was at fairly good grade level. The testing hypothesis of those data were attached in Table 2.

Table 2. Testing hypothesis of mean difference of MCS and MR in both teaching approaches.

| Variables | Teaching App. | x    | SD   | N   | Sig (2-tailed) | Sig (1-tailed) | Interpretation |
|-----------|----------------|------|------|-----|----------------|----------------|----------------|
| MCS       | PPA            | 33.51| 7.93 | 35  | 0.000          | 0.000 < 0.05   | MCS_{PPA} > MCS_{CT} |
|           | CT             | 24.51| 9.03 | 35  | 0.000          | 0.000 < 0.05   | N-Gain MCS_{PPA} > N-Gain MCS_{CT} |
| N-Gain    | PPA            | 0.52 | 0.17 | 35  | 0.000          | 0.000 < 0.05   | N-Gain MCS_{PPA} > N-Gain MCS_{CT} |
|           | CT             | 0.30 | 0.14 | 35  | 0.000          | 0.000 < 0.05   | N-Gain MCS_{PPA} > N-Gain MCS_{CT} |
| MR        | PPA            | 86.74| 9.58 | 35  | 0.925          | 0.465 > 0.05   | No difference |
|           | CT             | 85.91| 7.69 | 35  | 0.925          | 0.465 > 0.05   | MR_{PPA} and MR_{CT} |

Note:
MCS: Mathematical Creative Thinking Ability Ideal score: 34.
MR: Mathematical Resilience Ideal score MR: 200.

Analysis about student’s difficulties on solving MCS task, was determined by comparing mean score each item of MCS and its ideal score. Those comparison was illustrated in Table 3. The study found many students realized difficulties on MCS tasks, especially students taught by conventional teaching. Students getting treatment with PPA realized difficulties on no 2 and no 5 those were about originality and fluency on probability problems, while student taught by conventional teaching realized difficulties in all items MCS.

Table 3. Mean score of each item of student’s MCS in the both teaching approaches.

| Teaching approach | Desc. Stat. | No.1 | No.2 | No.3 | No.4 | No.5 |
|-------------------|-------------|------|------|------|------|------|
| PPPA              |             | 10   | 12   | 14   | 12   | 12   |
| PPA               | % of ideal score | 77.7 | 51.4 | 10.97 | 6.91 | 6.26 |
| CT                |             | 3.79 | 2.36 | 10.08 | 7.06 | 3.85 |
| CT                | % of ideal score | 37.9 | 19.67 | 72   | 58.83 | 32.08 |

Note:
PPA: problem posing teaching approach.
CT: conventional teaching.

Analysis of the relationship between MCS and MR using contingency tables and using testing and χ² testing. The study obtained value χ² = 8.220 and sig.(2 tailed-.084 > 0.005), it was meant was no association between MCS and MR.
### Table 4. Contingency table of MCS and MR in PPA class.

| MCS | MR  | High | Medium | Low | Total |
|-----|-----|------|--------|-----|-------|
| High|     | 1    | 3      | 0   | 2     |
| Medium| | 2    | 12     | 3   | 15    |
| Low | | 0    | 8      | 6   | 14    |
| Total | | 3    | 23     | 9   | 35    |

Considering student’s perception toward PPA, researcher found in the beginning lesson, students realized some obstructions in PPA, but after some sessions students accustomed to learning environment of PPA and tasks. Student in PPA class learned more active than students in conventional teaching and students performed positive opinion toward implementation of PPA. Beside positive student’s opinion toward PPA, observers also reported their positive impression to teacher’s activities as well, as follow. Teacher did well during PPA, he acted as facilitator and moderator during the lesson, he facilitated student’s opportunity to comment on other student’s opinion, and he helped student to reflect their work, and in general students learned actively.

### 3.2. Discussion
Finding in pre-test that was no difference on student’s grades of MCS between students getting treatment with PPA and students taught by conventional teaching, actually was rational. It caused of in both classes, students did not accept the new mathematics contents and MCS process yet. Further findings of this study were PPA took better role than conventional teaching on improving MCS, its N<Gain>, and on MR. Those findings were similar to findings of previous studies [12-14, 17, 20, 21] which reported advantages of PPA than conventional teaching on improving various mathematics abilities. This condition might be caused of each step of PPA namely accepting and challenging phase gave opportunity to students to improve MCS and MR. Besides that, these findings were in line with opinion of Lavy and Shriki such as PPA among other facilitated student to generate and improve student’s divergent and flexible thinking, to improve student’s curiosity, improved student’s reasoning and reflection abilities, and promoted student’s self confidence in constructing their knowledge [22]. Those aforementioned advantages of PPA supported indeed for solving MCS problems.

After some lessons, on MCS students getting treatment with PPA obtained better grades than the grades of students taught by conventional teaching. These findings were similar to the findings of other studies namely on MCS students getting treatment with various innovative teaching approaches obtained better grades than the grades of students taught by conventional teaching. Even though, those student’s grades on MCS were at low to fairly good grade level [1-4, 14-16, 22, 23]. Seemingly, MCS problems were difficult task for many high school students.

The low students’ grade on MCS, beside caused of MCS task was difficult task it might be students did not master yet the prerequisite of content and process of MCS as well. So it was suggested before teacher was going to teach a new mathematics content or process, it should be preceded by examining students’ mastering prerequisite of content and processes of mathematics will be learned. The suggestion was in line with constructivism philosophy among other: new information should be related to previous students’ knowledge in order student to obtain meaningful learning. Like that, the suggestion was relevant to the traits of nature of mathematics as well namely mathematics was a systematic and structured science, which it meant mathematics was a science compiled of inter-related mathematics concepts and or contents.

Likewise, finding of students’ grade on MR of this study, was similar to finding’s that was in junior high school students was no difference on students’ grades of MR and the grades were at medium level [15]. Even though, those findings were different with findings of Abdurrohim by using discovery learning [17] and Aryanto which implemented RME [18], found senior high school student attained at fairly good grade level on MR. Similar to value and character education, MR was not able to improve directly such as teaching mathematics contents. Finding on association between MCS and MR of this study, was similar to findings of two studies namely were no association between mathematical MCS...
with MR [15, 22]. But, those findings were different with findings of some other studies [1, 2, 23] which reported there were association between MCS and various mathematical soft-skills. Those findings indicated inconsistent findings on existence of association between MCS and various mathematical soft-skills.

About student’s impression on PPA, study found in the beginning lesson, students realized some obstructions in PPA, but after some sessions students accustomed to learning environment of PPA and tasks. Some obstructions among other were there was limited allocated time for the lesson, whereas students needed a longer time for exercising to pose problem and solving it, moreover posing problem task was a new task for students; students generated many and various problems indeed, but students realized difficulty in analyzing them; problem posing was difficult and complex task, so students should be patient and had high mathematical resilience to solve the task.

However, in further lesson, students performed positive opinion on implementation of PPA. Students expressed: student work sheet (SWS) made students challenge to learn new mathematics content; SWS presented mathematics content accompanied with picture and illustration so that easy to understand it; problem on SWS improved students’ higher order thinking ability, make students challenged, need to think, difficult but related to daily live, students more active to think critically, PPA more interesting than conventional teaching, learning environment interesting, enjoyable, not boring, relax but still focused, students were more active to learn, even though sometimes students boring with too difficult and complex problems which needed complicated rules.

Finding of this study such as student posed positive perception on PPA was similar to findings of some recent studies, namely student performed positive opinion toward scientific teaching approach [15], toward problem based learning [23], toward RME [25], toward contextual teaching [26]. Those findings illustrated the new implemented innovative approaches created please learning environment to student and motivated student to learn actively in improving MCS. Besides that, findings of this study implicated for obtaining better grades on MCS teacher should select relevant teaching approach to the traits of MCS.

4. Conclusion
The problem posing approach took better role than conventional teaching on improving students’ mathematical creative skill and its gain, but student’s grades were at low to medium level and on mathematical resilience students’ grades were at medium level. Besides that, students getting treatment with problem posing approach realized few difficulties, while students taught by conventional teaching realized difficulties in all items in solving mathematical creative skill problems, The other conclusion were students performed high perception on problem posing approach, and they demonstrated active learning during the lessons and there was no association between mathematical creative skill and mathematical resilience.

References
[1] Wardani S, Sumarmono U and Izumi N 2011 Mathematical Creativity and Disposition: Experiment with grade-10 students using Silver Inquiry Approach Math. Creat. Dispos. Exp. with Grade-10 Students Using Silver Inq. Approach 59 1–16.
[2] Rohaeti E E, Budiyanto A M and Sumarmo U 2014 Mathematical Logical Thinking Ability and Self-Regulated Learning of Students through Problem Based Learning Int. Educ. 8 54–63.
[3] Widyaningtyias R 2015 Pengaruh Pendekatan Pembelajaran Berbasis Masalah terhadap Kemampuan dan Disposisi Berpikir Kritis dan Kreatif Matematis Siswa SMA (Universitas Pendidikan Indonesia).
[4] Rosita 2016 Meningkatkan Kemampuan Berfikir Kreatif Matematis dan Kemandirian Belajar Siswa dengan Menggunakan Model Pembelajaran Brain Based Learning J. Pendidik. UNSIKA 4 26–41.
[5] National Council Of Teachers Of Mathematics 2000 Principles and standards for school mathematics.
[6] Pucio G J and Murdock M C 2001 Creative Thinking, an Essential Life Skill *Developing Minds. A Resource Book for Teaching Thinking* (Virginia, USA: Association for Supervision and Curriculum Development).

[7] Hendriana H, Rohaeti E E and Sumarmo U 2017 *Hard Skill dan Soft Skill Matematika Siswa* (Bandung: Refika Aditama).

[8] Munandar S C 1987 *Creativity and Education* (Jakarta: Departemen Pendidikan dan Kebudayaan).

[9] Klohnen E . 1996 Conceptual Analysis and Measurement of the Construct of Ego Resiliency *J. Pers. Soc. Psychol.* 70 1067–79.

[10] Sumarmo U 2015 *Resiliensi Matematik (Mathematical Resilience)* (Cimahi: STKIP Siliwangi).

[11] Brown S I and Walter M I 2005 *The Art of Problem Posing* (London: Lawrence Erlbaum Associates).

[12] Abu-Elwan R 2000 Effectiveness of Problem Posing Strategies on Prospective Mathematics Teachers’ Problem Solving Performance *Online*.

[13] Guvencin S and Verbovskiy V 2014 The Effect of Problem Posing Tasks Used in Mathematics Instruction to Mathematics Academic Achievement and Attitudes Toward Mathematics *Int. Online J. Prim. Educ.* 3 59–65.

[14] Rosyana D, Supandi and Ariyanto L 2016 Meningkatkan Kemampuan Berfikir Kreatif Matematis Pada Siswa Kelas VIII Melalui Pembelajaran Problem Posing *Seminar Nasional Matematika dan Pendidikan Matematika* (Semarang: Universitas PGRI Semarang).

[15] Koswara D 2017 *Meningkatkan Kemampuan Berpikir Kritis dan Kreatif serta Resiliensi Matematik Siswa SMP melalui Pendekatan Saintifik* (STKIP Siliwangi).

[16] Setiawati E 2014 Mengembangkan Kemampuan Berpikir Logis, Kreatif, dan Mathematical Disposisi Matematis, melalui Pembelajaran Berbasis Masalah (Universitas Pendidikan Indonesia).

[17] Abdurrohim S 2017 *Meningkatkan Kemampuan Pemecahan Masalah dan Komunikasi serta Resiliensi Matematik Siswa SMA melalui Pendekatan Discovery Learning* (STKIP Siliwangi).

[18] Murni S and Sugandi A I 2018 The Role of Mathematics Realistics Education on Students’ Mathematical Critical Thinking and Resilience *J. Math. Inov. Learn.* 1.

[19] Aryanto L, Herman T, Sumarmo U and Suryadi D 2017 Developing Mathematical Resilience of Prospective Teachers *J. Phys. Conf. Ser.* 895.

[20] Hendriana H and Sumarmo U 2014 *Penilaian Pembelajaran Matematika* (Bandung: Refika Aditama).

[21] Putra H D 2017 Pengembangan Instrumen untuk Meningkatkan Kemampuan Matematik Problem Posing Siswa SMA *J. Euclid* 4 636–45.

[22] Lavy I and Shriki A 2007 Problem Posing as a Means for Developing Mathematical Knowledge of Prospective Teachers *Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education* pp 129–36.

[23] Krismayanti R 2017 *Meningkatkan Kemampuan Pemecahan Masalah dan Berpikir Kreatif Matematik serta Self Efficacy Siswa SMP melalui Pembelajaran Berbasis Masalah* (STKIP Siliwangi).

[24] Hendriana H 2017 Teachers’ hard and soft skills in innovative teaching of mathematics *World Transactions on Engineering and Technology Education* vol 15 pp 145–50.

[25] Murni S 2017 *Meningkatkan Kemampuan Berpikir Kritis dan Kreatif serta Resiliensi Matematik Siswa SMA Negeri di Cimahi melalui Pendekatan Realistic Mathematics Education* (STKIP Siliwangi).

[26] Ruhayat A and Sugandi A . 2017 Meningkatkan Kemampuan Berpikir Kreatif dan Disposisi Matematik Siswa SMP dengan Menggunakan Pendekatan Kontekstual *J. Ilmu Pendidik. dan Pengajaran* 3 281–9.