Nitrogen Cycle Ninja, A Teaching Exercise

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ABSTRACT

Long-term student retention and understanding of information is the goal of virtually all teachers/instructors/professors. One exercise was evaluated for its effectiveness to improve student retention of the nitrogen (N) cycle. This was conducted within a 3-h course entitled Soil–Plant Relationships that had a mix of M.S. and Ph.D. students. The N cycle was thoroughly discussed in class and students had prior knowledge that this information could be requested on unannounced quizzes. One week after this was discussed, an unannounced quiz was given and students were asked to provide a complete graphic N cycle. Prior to handing out the quiz, they were informed that proper completion of this material would qualify them as a Nitrogen Cycle Ninja (def: 1: individual with constant awareness and understanding of N dynamics, 2: warrior, perpetually ready for battle, and pursuing truth of all concepts as they relate to N in soil–plant systems) and they would receive a card that authenticated that achievement. Also, once this information was adequately learned, they could use their card (which had a miniature N cycle and list of all components) on all subsequent exams. Non Ninja card holders would not benefit from this privilege. Ninja status could only be achieved on unannounced quizzes, a sign of constant awareness and understanding of N dynamics. On the first quiz, only two students received their Ninja card. By the second pop quiz on the N cycle (given 14 d later), 16 of 17 students were certified Nitrogen Cycle Ninjas. An anonymous postclass student survey found that most students were pleased with the exercise. Three months after the final exam, 11 students were given impromptu visits and asked to provide the complete graphic N cycle, in addition to all components discussed in class. Six of the 11 students that were retested would have retained their Ninja cards. Students commented that similar approaches could be used for other subject materials. Also, most students noted that the exercise was fun, which increased their motivation to learn.

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Contribution from the Oklahoma Agric. Exp. Stn. Received 16 Aug. 1996.
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Published in J. Nat. Resour. Life Sci. Educ. 26:39–42 (1997).

THOROUGH UNDERSTANDING of the N cycle provides relevant and useful information to professionals in academic, private, and public sectors. Failure to understand one or more components of the N cycle can lead to misinterpretation of information as it relates to fate of mineral and organic N fertilizers. For graduate students in soil and crop sciences, retention of the information included in N cycling in plants and soils is critical, since N is the most limiting nutrient for crop production worldwide.

Methods of improving retention of information have been evaluated in virtually all scientific fields. Recent work has focused on the differences associated with problem solving approaches vs. subject matter approaches. Flowers and Osborne (1988) noted that the problem solving approach is no more or less effective than the subject matter approach as measured by student achievement, regardless of the cognitive level of the questions. However, they further noted that for high level cognitive items, the problem solving approach resulted in lower achievement loss. More recent work by Boone (1990) indicated that the problem solving approach to teaching increased the level of student retention of agricultural knowledge. This approach offered the opportunity to solve real problems as a part of their classroom instructions.

Table 1. Outline used to comprehensively address the N cycle for graduate students in soil and crop sciences.

- I. Organic matter
  - Addition
    - Symbiotic fixation
    - Nonsymbiotic fixation
    - Fertilizer
      - Organic
      - Inorganic
  - Removal
- II. Volatilization (fertilizer addition)
- III. Mineralization
  - Aminization
  - Ammonification
  - Fixation (exchange)
  - Nitrification
- IV. Immobilization
- V. Denitrification
- VI. Gaseous Plant N Loss
- VII. Leaching
- VIII. Oxidation states of N
- IX. C/N ratio of the organic matter
- X. Soil-plant inorganic N buffering

Long-term student retention and understanding of information is the goal of virtually all teachers/instructors/professors. However, measuring long-term retention is difficult since students leave and are seldom revisited in a setting where this can be evaluated. Holcomb et al. (1982) suggested that a 6-mo time interval represented a long-term retention measure. While 6 mo is better than 7 d, most instructors would like to see retention approach years.

The present study was stimulated by a presentation from James (1995) in which innovative methods of teaching (use of poetry in science) were discussed. The objectives of this exercise were: (i) to improve retention of N cycle information via a combined peer pressure-status approach that was expected to increase participation (Nitrogen Cycle Ninja member) and (ii) to assess student response related to this activity.

MATERIALS AND METHODS

One competitive peer pressure-status exercise was evaluated to improve student retention of the N cycle. This exercise was conducted within a 3-h course entitled Soil–Plant Relationships that is taught primarily to M.S. and Ph.D. students in soil, crop, and range sciences. Five, 50-min lectures were used to completely discuss the N cycle. Prior to this, three lectures addressed the composition of organic matter, carbon (C)/N ratios of different organic materials, a brief overview of the C cycle, factors affecting the decomposition of organic matter, and microbial action on organic matter. Once this was complete, the N cycle was discussed in what was considered to be a logical sequence (Table 1). Supplemental text information concerning the N cycle was derived from Alexander (1977) (chapters 15–19). Work by Raun and Johnson (1995) and Johnson and Raun (1995) was used for detailed discussion of N-cycle components related to soil–plant inorganic N buffering.

Once this was complete, students were informed that a pop-quiz would be given in which they would be asked to provide a detailed sketch of the N cycle. From class, an improved version (previously developed in this class) of the N cycle was distributed to all students that included the influence of temperature, moisture, oxidation, and reduction on N transformations (Fig. 1). One week after this was discussed, an unannounced quiz was given and students were asked to provide a comprehensive diagram of the N cycle. Prior to handing out the quiz, they were informed that proper completion of this material would qualify them as a

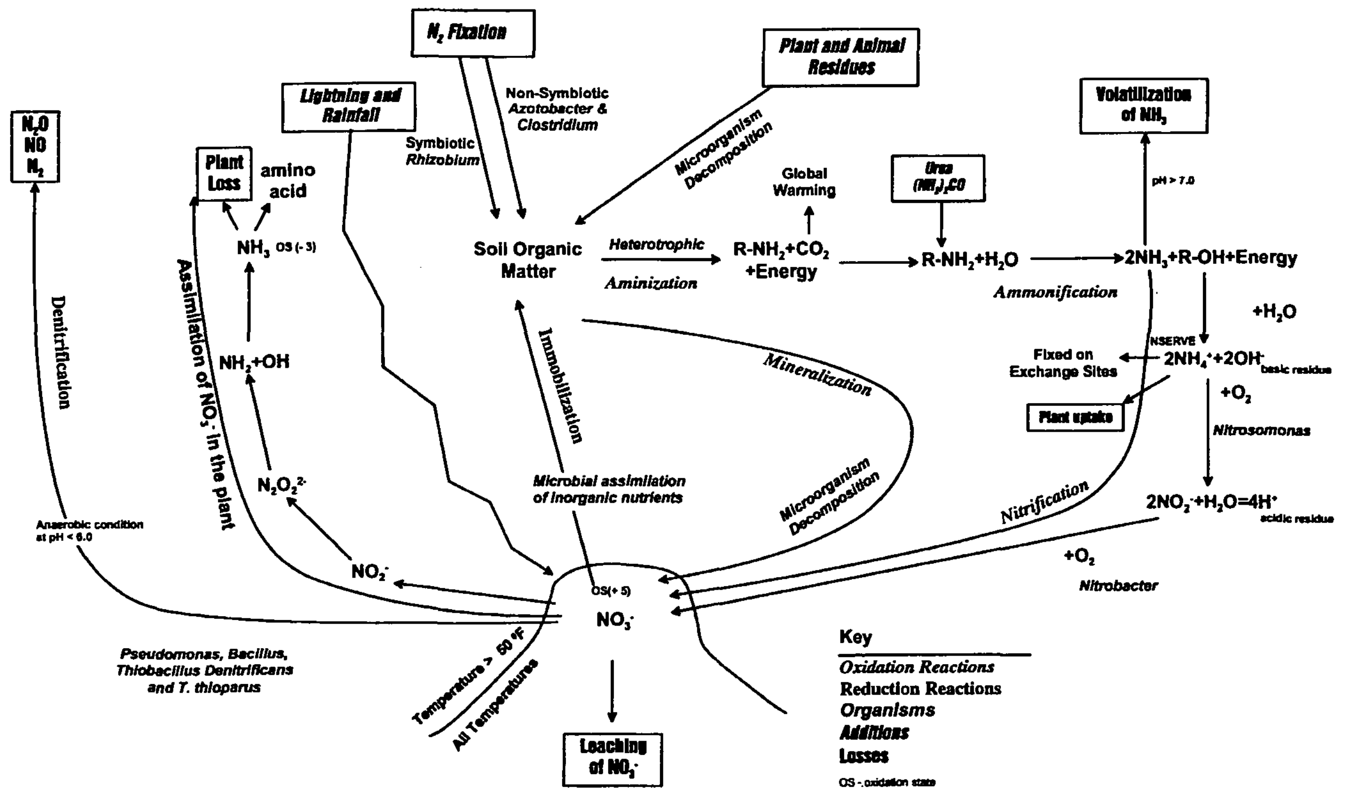
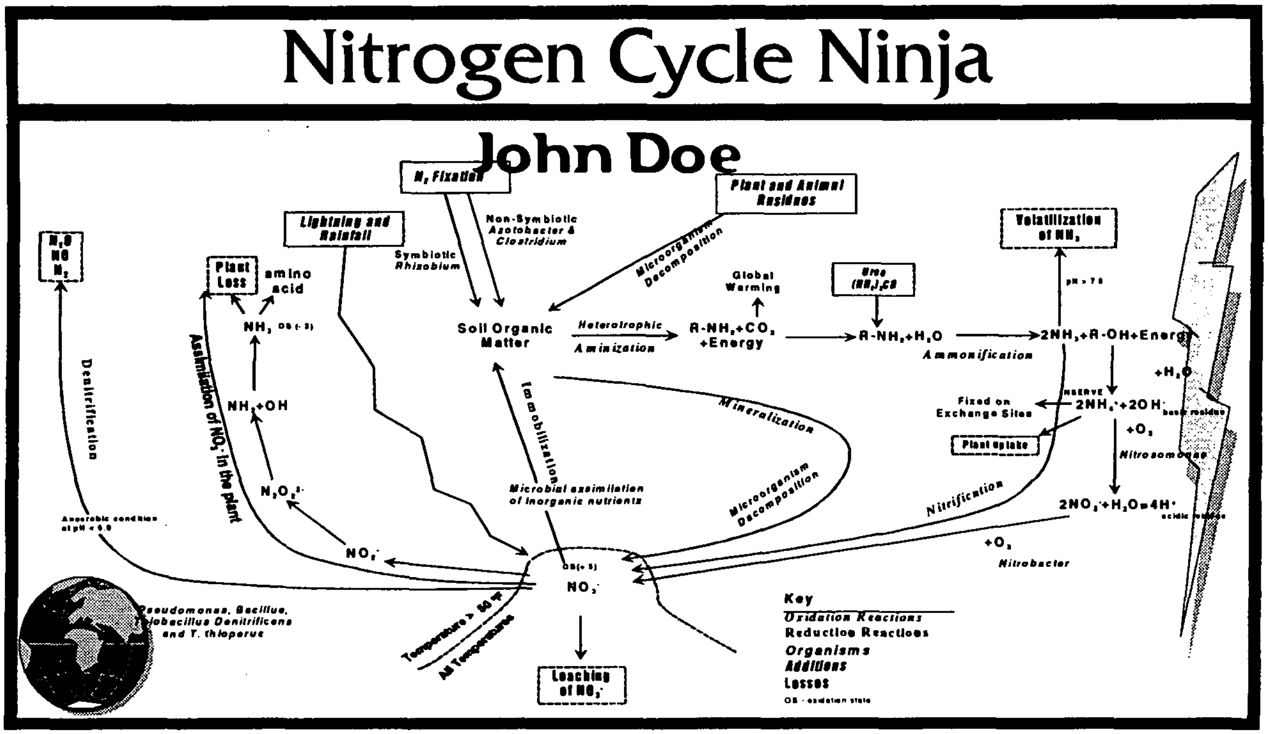


Fig. 1. Graphic representation of the complete N cycle that was distributed to students involved in the Nitrogen Cycle Ninja exercise.

Nitrogen Cycle Ninja and that they would be given a card that authenticated that achievement. The card included their name, a miniature N cycle on the front and a list of all components that needed to be addressed for Ninja status on the back (Fig. 2). The card was laminated and printed in color, following adequate attention devoted to finding an appealing design. Once all required N cycle information was adequately learned, they could use their card on all subsequent quizzes and hour exams. Non Ninja card holders would have to continue answering the N-cycle test question from memory alone. Ninja status could only be achieved on unannounced quizzes, a sign of constant awareness and understanding of N dynamics. Each student was expected to be a warrior, perpetually ready for battle and pursuing truth of all concepts as they related to N in soil–plant systems.



The cardholder is a certified Nitrogen Cycle Ninja as judged by an authorized representative. He or She has a complete and thorough understanding of all terms listed on this card.

N fixation, non-symbiotic fixation, blue green algae, azotobacter, clostridium, symbiotic fixation, rhizobium japonicum, meliloti, trifoli, organic matter, animal and plant residues, decomposition, aminization, R-NH_2 + CO_2, urea, ammonification, nitrification, oxidation, aeration, NH_3 + R-OH + energy, volatilization, fixation, mineralization, (OS-3)NH_4, nitrosomonas, O_2, NO_2, nitrobacter, obligate autotrophic bacteria, increased acidity, NSERVE, (OS+5)NO_3, leaching, immobilization, denitrification, organic C, substrate, pseudomonas denitrificans, thiobacillus denitrificans, NO, N_2O, N_2, immobilization, plant uptake, nitrate reductase, nitrite reductase, plant N loss, N in rainfall, oxidative metabolism-photosynthesis, nitrate reduction, urea, pH-controlled, global warming, reduction, oxidation state, effect of temperature and moisture.

NCN representative

Fig. 2. Nitrogen Cycle Ninja cards developed for students with a demonstrated comprehensive understanding of the N cycle. Top = front of card. Bottom = back of card.

Table 2. Mean, range, and standard deviation values from a post class survey given anonymously to students participating in the Nitrogen Cycle Ninja exercise (scale 1–5, 1 = definitively yes, 5 = definitively no).

Question	Mean	Range	Standard deviation
1. Is having a thorough understanding of N-cycle dynamics important/	1.19	1–2	0.40
2. Do you feel comfortable with N-cycle dynamics having covered much of this in class?	1.44	1–2	0.51
3. As has been taught in this class, will you be able to use this information on N-cycling in the workplace?	1.31	1–2	0.48
4. Did the Nitrogen Cycle Ninja exercise motivate you to better learn N-cycling dynamics?	1.50	1–4	0.97
5. Does this kind of exercise (Nitrogen Cycle Ninja) merit consideration in other classes?	1.56	1–4	0.89
6. If you were a teacher, would you ever consider doing something similar (Nitrogen Cycle Ninja) to improve communication and understanding of a specific topic?	1.19	1–2	0.40
7. If you did consider the Nitrogen Cycle Ninja to be useful, please indicate why?			
It was motivational and added good interaction between the students and the instructor			
It gave me an incentive to learn the material. The reward was trivial but it encouraged competition among students to get his/her card. This exercise made learning the material fun and even graduate students who should learn for the sake of learning like to have fun			
It allowed me to understand what path N takes when it is in the soil and how N should be placed in the soil			
It helped motivate us to learn. This exercise was unusual, and not the norm for other classes			
It was extra motivation to learn the N cycle and it made learning this material fun and exciting			
Even though students are inherently lazy, most would prefer to know and understand the material. The Nitrogen Cycle Ninja exercise added some motivation with a residual effect of personal pride			
Nobody wants to be the last person to get their card. It forces the class to be competitive			
8. If you did not consider the Nitrogen Cycle Ninja exercise to be useful, please indicate why?			
I am not motivated to learn this way!			
It was not a motivational factor for me!!			

Once all students achieved Nitrogen Cycle Ninja status, a questionnaire was distributed that allowed students to remain anonymous. The questionnaire addressed positive and negative attributes associated with the exercise and willingness of students to be involved in similar exercises as it related to different subject matter.

RESULTS AND DISCUSSION

On the first quiz, only two students completed the N cycle in a satisfactory manner, clearly illustrating and documenting all components listed in Fig. 1. By the second pop-quiz on the N cycle (given 14 d later), 16 of 17 students were certified Nitrogen Cycle Ninjas. By the third pop-quiz concerning the N cycle (given 4 wk after the first quiz on the N cycle), all 17 students were judged to be true warriors and field-ready Nitrogen Cycle Ninjas.

Results from the anonymous postclass student survey are reported in Table 2. In general most students were pleased with the exercise. Although the overall means were between 1 and 2 (all questions phrased in a manner to reflect whether or not they were in favor or against this exercise, 1–5 scale, 1, definitively yes; 5, definitively no), results from questions 4 and 5 clearly illustrate that not all students agreed with this kind of approach (large standard deviation). Two of 17 students ranked questions 4 and 5 with a score of 3 or 4, even though remaining students appeared to be pleased with the Nitrogen Cycle Ninja exercise. However, it was interesting to note that even those students who were apparently opposed to the Nitrogen Cycle Ninja exercise (question 4) must have considered this method worthy in another setting since only 1's and 2's were reported for question 6. Instructors in general need to get used to the fact that it is impossible to please all students; however, independent of the instructor, if students are in agreement with the teaching concept, learning will occur. The anonymous survey also included two added questions that solicited written comments that were either pro or con. Positive comments generally had one central theme, increased interest in subject matter led to increased motivation that ended up being fun. Negative comments noted that this was not a motivational tool (Table 2).

Three months after the final exam, several students were given surprise visits (out of classroom settings) and asked to provide the complete graphic N cycle again. Six of the 11 students that were retested would have retained their Ninja status, based on the information they provided on an impromptu basis.

The reasons we think this exercise was successful are listed below.

1. Information from the N cycle had to be available at all times since testing for Ninja status was only achieved via performance on pop quizzes.
2. Students applied peer pressure on one another to obtain the Ninja card, since no one wanted to be left behind.
3. Those students who obtained their Ninja cards could use the information printed on the card on either quizzes or exams which other students who did not have Ninja status noticed.
4. Continued testing took place until all students acquired Ninja status. No one wanted to be last.

The exercise was meant to be and ended up being fun. All instructors search for education tools that increase retention and actively involve all students in the classroom. This exercise helped to achieve our goal of increasing student participation and ultimate understanding of N cycle information.

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