Correction to: A Critical Review of Students' and Teachers' Understandings of Nature of Science

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The original article unfortunately contains incorrect presentation of Tables 1, 3, 4, 5 and 6.

The correct presentation of Tables 1, 3, 4, 5 and 6 are shown below.

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Table 1 Summary of studies about NOS understanding in **Elementary School students (K-6)** analysed. NOS aspects are: T= Tentativeness, O&I = Observation and inference, S=Subjectivity, C=Creativity and Imagination, E=Empirical based, S&C=Socially and Culturally embedded; Int = integrated activities. Exp = Explicit and Imp = Implicit. Data at Results column correspond to % of students in informed category before and after intervention

Authors	Duration (n)	Grades	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instrument
1. Khishfe & Abd-El-Khalick (2002)	10 weeks (62)	Sixth grade	Content course	Int	Inquiry activities & reflection	The most naive was T and the most informed was C	The aspect that most improve was T and the least improve were C and O&I	T: 6 → 52 O&I: 9 → 40 E: 6 → 48 C: 3 → 34	VNOS items
2. Akerson and Volrich (2006)	13 weeks (14)	First grade	Content course	Non-Int and Int	reflexive activities	The most naive was T and the most informed was O & I.	The aspect that most improved was C and the least improved was O&I	T: 14 → 14 C: 12 → 14 O: 14 → 14	Interviewed using VNOS-D
3. Akerson & Donnelly (2010)	6 weeks (18)	K to second grade	Informal inquiry & NOS course	non-int & int	Inquiry activities & reflection	The most naive was O&I and the most informed was E.	The aspect that most improved were C and O&I and the least improved was S.	C: 17 → 18 T: 14 → 18 E: 12 → 18 O&I: 17 → 18 S: 9 → 18	Conversations related VNOS-D
4. Quigley et al. (2010)	6 weeks (25)	K to second grade	Informal inquiry & NOS course	Int	Inquiry activities & reflection	The most naive was S and the most informed was E	The aspect that most improved was T and E and the least improved was S&C	Overall the students improved their understanding of the target aspects of NOS. There was still some confusion regarding the distinction between observation and inference.	Qualitative approach based on the VNOS-D
5. Yacoubian & Boulalaude (2010)	8 weeks (38)	Sixth grade	Inquiry course	Int	Inquiry activities & reflection	The most naive was S and the most informed was T	The aspect that most improve was E and the least improve was T	T: 15 → 15 E: 0 → 45 S: 0 → 25 Social: 0 → 30	POSE
6. Akerson et al. (2014)	1 year	Third grade	Content course	Int	reflexive activities	The most naive was S and the most informed was E	The aspect that most improve was S and the least improve was T	O&I: 56 → 63 E: 94 → 94 S: 25 → 39 T: 38 → 50	VNOS-D2
7. Papadouris & Constantinou (2014)	5 weeks	Sixth grade	content course	Int	HOS and	inquiry-oriented activitiesengaging students in	All naive views at the beginning	Most of students develop more sophisticated	Students became better positioned to recognize

Table 1 (continued)

Authors	Duration (n)	Grades	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instrument
Interview 8, Foud et., al (2015)	6 weeks (17)	Second, third, and fourth grade	Content course	Non-int & int	Inquiry vs. HOS	The most naive was S and the most informed was C and T	The aspect that most improved was C and least improved were O&I and T	epistemology of C, E and O&I Changes in number of students at informed category (summary of four grades) Inquiry group E: 0→1; T: 1→0 C: 0→1; S: 0→1 O & I: 0→1-2 History group E: 0→1 -1; T:(text-books) 0→0; T, C (dinosaurs) +1→1-1; S: 0→0 O & I: (weather) 1→1	observations and interpretations and to differentiate between them, based on epistemological criteria VNOS-D
9, Michel & Neumann (2016)	4,5 h.	Sixth and seventh grade	content course	Non-int & int	Generic NOSActivities	The article did not show previous view of NOS	Five NOS aspects were studied (C, O&I, S, T, T&L).	Students did not changed scores on the NOS instrument. But a more adequate NOS view was relating to students' understand of nature of energy.	NOSSI and VNOS-C

Table 3 Summary of studies about NOS understanding in **Pre-service elementary teachers**. NOS aspects are: T= Tentativeness, O&I = Observation and inference, S=Subjectivity, C=Creativity and Imagination, E=Empirical based, S&C=Socially and Culturally embedded, T&L=Theory and Law, SM =Scientific method. Int = integrated activities. Exp = Explicit and Imp = Implicit. Data at Results column correspond to % of teachers in informed category before and after intervention. Data at Results column correspond to % teachers in informed category before and after intervention

Authors	Duration (n)	Course	Context	Strategies	Pretest views	Posttest views	Results	Instruments
1. Akerson, et al. (2000)	1 semester (50)	science methods course	Non-int	Activities + reflection + reading	Most naïve aspect was T&L and most informed was S&C	Most improve were T, T&L and C and the least improve was S	E: 4 → 32 T: 8 → 72 C: 24 → 80 S: 32 → 52 S&C: 56 → 80 O&I: 40 → 80 T&L: 4 → 48	VNOS
2. Abd-El-Khalick and Akerson, (2004)	1 semester (28)	science methods course	Non-int	Activities + reflection & reading papers	Most naïve aspects were T&L and T and the most informed was E	Most improve was C and the least improve was E	E: 29 → 71 T: 11 → 64 C: 18 → 86 S: 18 → 82 O&I: 25 → 75 T&L: 11 → 75 SM: 14 → 68	VNOS-B
3. Akerson et al. (2006)	1 semester (19)	science methods course	Int and non-int	Reading, hands-on activities + reflection	Most naïve aspect was T&L and most informed was T	Most improve were T&L and C and the least improve was E	All aspects show improved views, but after 5 months, T, C, S, E, S&C and O&I reverted	VNOS-B
4. Matkins & Bell (2007)	1 semester, 13 h (15)	science methods course	Int (highly contextualized) and non-int	Activities + reflection & SSI elements	Most naïve aspects were T, C and S&C and most informed was E	Most improve was C and the least improve was S&C	E: 27 → 73 T: 0 → 60 C: 0 → 67 S: 20 → 80 S&C: 0 → 27 E: 12 → 68	Views of Science and Global Climate Change Questionnaire
5. Abd-El-Khalick and Akerson, (2009)	1 semester (25)	science methods course	Non-int	Activities + reflection & metacognition, & hands-on activities	Most naïve aspects were T and O&I and most informed was E	Most improve were T and O&I and the least improve was S	T: 8 → 72 S: 0 → 48 O&I: 0 → 64 C: 8 → 56	VNOS-C
								VNOS-C

Table 3 (continued)

Authors	Duration (n)	Course	Context	Strategies	Pretest views	Posttest views	Results	Instruments
6. McDonald (2010)	11 weeks (5)	science content course	Int (highly contextualized)	Inquiry activities + SSI & HOS elements + argument	Most naïve aspect was T&L and most informed were O&I and T	Most improve was S and the least improve were O&I, E, T and S&C	Developed aspects in 4 or 5 participants: SM, S Unchanged aspects in 4 or 5 participants: T&L, T	
7. Bell et al. (2011)	1 semester (75)	science methods course	Int (highly contextualized) and non-int	Activities + reflection vs. SSI elements	Most naïve aspect was T&L and most informed E	Most improve was T&L and the least improve was S	Best treatment: E: 17 → 90 T: 6 → 72 C: 11 → 83 S: 17 → 67 O&I: 6 → 56 T&L: 0 → 78	VNOS-B
8. Akerson et al. (2012)	1 semester (17)	science methods course	Int and non-int	Reading + assignments + activities + reflections Focus in cultural values	Most naïve aspect was T&L and most informed C	Most improve was O&I and the least improve was E	T: 0 → 63 O&I: 0 → 81 T&L: 0 → 25 E: 13 → 31 C: 19 → 75 S: 13 → 56 S&C: 13 → 56	VNOS-B
9. Özgelen et al. (2013)	1 semester (34)	science lab course	Int and non-int	Inquiry activities + reflection	Most naïve aspect was T&L and most informed C	Most improve was S and the least improve was T	E: 3 → 18 O&I: 0 → 18 T&L: 0 → 29 S: 0 → 44 T: 0 → 12 C: 15 → 79 S&C: 0 → 24	VNOS-B

Table 4 Summary of studies about NOS understanding in **Pre-service secondary teachers** analysed. NOS aspects are: T= Tentativeness, T&L= Theory and Law, NFT= Nature and Function of Theories, O&I = Observation and inference, S=Subjectivity, C=Creativity and Imagination, E=Empirical based, S&C=Socially and Culturally embedded, SM =Scientific method. Int = integrated activities. Exp = Explicit and Imp = Implicit. SMC = Science Method Course. Data at Results column correspond to % teachers in informed category before and after intervention

Authors	Duration (n)	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instrument
1. Lin & Chen (2002)	1 semester (63)	SMC and History of Science course	Int (highly contextualized)	HOS, group discussions, debates, demonstrations, hands-on experiments, readings	No creativity in science, scientist simply discover by good luck; explanations are based on intuition; theories are facts that have been repeatedly confirmed	Scientist may create different theories for a same phenomenon; explanations are based on scientific experiments; theories are tools for explaining natural phenomena	Experimental group understand better C, the theory-based nature of O&I, and the functions of Theories	VOSTS (modified)
2. Schwartz et., al (2004)	10 weeks (13)	Internship in science course	Int	Real research experience & reflection	The most naive was T&L and the most informed was T	The aspect that most improved was S the least improved was SM	Number of students teachers in category: major change or enhanced E: 9; T: 8 S&C: 9 S:10; C: 9 T&L: 8 O&I:9 SM: 7	VNOS-C
3. Abd-El-Khalick (2005)	2 years (56)	SMC and Philosophy of Science course	Non-int	Generic explicit activities, readings, whole-class discussions, NOS-specific reflection papers, inquiry activities	The most naive were S and T&L and the most informed was S&C.	The aspect that most improved were T&L and E and the least improved were S and S&C.	POS course participants developed deeper and more coherent understandings of NOS compare with methods course participants	VNOS-C
4.	52 h distributed in 2 months (9)	Science methods course	Non-int and int	Explicit teaching, "practice"		Both aspect improve in the same way	Positive changes in the preservice	VOSI

Table 4 (continued)

Authors	Duration (n)	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instrument
Lotter, Singer & Godley (2009)				teaching experiences, readings, reflection papers	The most naive was S and the most informed was SM		teachers' views of NOS in terms of sophistication	
5. Seung et., al (2009)	2 semester, 12 h (10)	Science methods course	Non-int & int (highly contextualized)	Inquiry lab & reflection + HOS	The most naive were SM and E, and the most informed was S	The aspect that most improved was E and the least improved was C	E: 0→7 O&I: 1→7 SM: 0→6 T: 4→9 S: 8→10 C: 0→1	VNOS
6. Herman & Clough (2016)	3 years of a secondary science teacher education program with emphasis on NOS in 9 courses (13)	Secondary science methods courses, Nature of Science and Science Education course, Restructuring Science	Non-int & int	Inquiry, questions regarding NOS	42% of the collective responses provided by participants on pre-NOS course VOSTS items were informed	82% of the collective responses provided by participants on post-NOS course VOSTS items were informed.	NOS course positively impacted understanding of NOS. % of informed collective responses: 42→82	VOSTS & SUSSI
7. Mesci & Schwartz (2017)	13 months (14 elementary and secondary science teachers)	Activities course NOS and Science Inquiry course	Non-int and int	Readings, concept map, laboratory activities, discussions,	The most naive was T&L and the most informed was O&I	The aspect that most improved were C and S, and the least improved was S&C	T: 0→21.4 C: 0→64.2 S: 0→28.5 O&I: 0→28.5 E: 0→21.4 T&L: 0→28.5 SM: 14.2→78.5 S&C: 0→7.14	VNOS; VOSI & SUSSI

Table 5 Summary of studies about NOS understanding in service elementary teachers analysed. NOS aspects are: T= Tentativeness, O&I = Observation and inference, S=Subjectivity, C=Creativity and Imagination, E=Empirical based, S&C=Socially and Culturally embedded, SM =Scientific method, Int = integrated activities, Exp = Explicit and Imp = Implicit, PDP = Professional development programme. Data at Results column correspond to % teachers in informed category before and after intervention

Authors	Duration (n)	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instruments
1. Abd-El-Khalick (2001)	6 months (30)	Semester-long physics course.	Int	Reflex explicit NOS activities, familiar and non-familiar content	The most naïve were C, S and T&I and the most informed was O&I	The aspect most improved was O&I and the least improved was S	% of students at naïve category. T&I: 40→17 O&I: 30→13 C: 67→67 S: 63→60	VNOS
2. Akerson et. al (2007)	2 weeks (14)	Summer PDP, NOS and Inquiry course	Int and non-int	Guided inquiry, reflex, activity	The most naïve were E and O&I The most informed was C	The aspect most improve was S&C and the least improved were C	More informed answers in post workshop questionnaire	VNOS-D2
3. Akerson et al (2009a)	2 weeks + 1 year follow up (4)	Summer PDP	Int	modelling, inquiry	The most naïve were S&C and T, The most informed was C	The most improve were S&C and O&I.	More informed answers in post-school year questionnaire	VNOS-D2
4. Akerson et al (2009b)	1 years (15)	PDP program	Int and non-int	Guided inquiry, reflex, act, Community of practice, action research focused on NOS assessment	The most naïve was S&C. The most informed was C.	The most improve were O&I, T, E, C, S&C	More informed answers after the summer workshop. Most advances lost after one year, excepting O&I	VNOS-D2
5. Morrison et al., (2009)	2 weeks (20)	Summer PDP with internship	Non-int & int	Act+ reflex. & reading p. & science internship, micro teach.	The most naïve was T&I and the most informed was T.	The most improve was C and the least improved was T&I.	T: 5→35 C: 0→50 S: 5→30 E: 5→10 S&C: 0→20 T&I: 0→5 O&I: 0→15	VNOS-B
6. Posnanski (2010)	2 years (22)	PDP	Non-int & int	Act. readings, reflex, collaborative teaching design, action research	The most naïve were T&I and O&I the most informed were S, S&C	The most improve was C. The least improved were T&I and O&I	% by NOS aspects are not available, but average rubric scores change from 13,57→17,20 after intervention	VNOS-C

Table 5 (continued)

Authors	Duration (n)	Courses	Context	Strategies	Pre-test views	Post-test views	Results	Instruments
7. Cofré et al., (2014)	1 year 60 h (12)	PDP, 2 NOS/SI course & 5 subject courses	Non-int & int	Act+ inquiry lab with reflex.	The most naive were T, C and O&I, and the most informed was E	The most improve was S. The least improve was E.	T: 0 → 34 C: 0 → 41 O&I: 0 → 41 S: 9 → 50 E: 83 → 83	VNOS-D+
8. Deniz & Adbelli (2015)	12 weeks (4)	Graduate level course	Non-int	Reading, hands-on activ, reflex explicit NOS activities	The most naive were O&I and the most informed were C, T, S	The most improve was O&I and the least improve was E	Number students in informed category E: 1 → 1 O&I: 0 → 1 C: 2 → 4 S: 2 → 4 T: 2 → 3	VNOS-B
9. Adbelli & Deniz (2017)	6 months (4)	PDP with two phases: NOS training and NOS teaching	Non int	Reading, teaching materials	The most naive were O&I and S&C and the most informed was E.	The aspect most improved was E and the least improved were S	More informed views after intervention, but not specific numerical data	VNOS-D2

Table 6 Summary of studies about NOS understanding in service secondary teachers analysed. NOS aspects are: T= Tentativeness, T&L= Theory and Law, O&I = Observation and inference, S=Subjectivity, C=Creativity and Imagination, E=Empirical based, S&C=Socially and Culturally embedded, SM =Scientific method. Int = integrated activities. Exp = Explicit and Imp = Implicit. Data at Results column correspond to % teachers in informed category before and after intervention

Authors	Duration (n)	Course	Context	Strategies	Pretest views	Posttest views	Results of Effectiveness	Instrument
1. Nehm & Schonfeld (2007)	14 weeks (44)	Graduate biology course	int	Exposure to misconceptions, collaborative learning, readings, videos	Focus in Theory and Law and its relationship with evolution. Evolution is weak because is a theory; Theories become facts	Positive and significant increase in teacher knowledge of NOEVO	Statistically significant increase in teacher knowledge of NOS	Likert-type items and essay questions
2. Wong, Hodson, Kwan, & Yung, (2008)	4 h (52)	Workshop	int	Multimedia teaching materials, individual tasks, group discussion, and problem-solving activities	Most naive: "science influences political decisions" (0%) and "social and cultural practices" (0%), "scientists should not submit to authority" (0%) and "scientist are competitive by nature" (0%). Most informed: science is affected by social and cultural (56%)	All NOS aspects improved. Most improved: "Science and technology impact each other" (65%). Least improved "Science influences political decisions" (19%)	Increase (%) of participants showing good understanding of: NOS & Society: 34.6 Scientist: 41.5.	VNOS-C (modified)
3. Niaz (2009)	11 weeks (17 secondary and college level)	Graduate chemistry education course	Int (highly contextualized)	HPOS Readings, written reports, classroom discussions, presentations, written exams	Qualitative description of misconceptions such as: universal scientific method, science is objective - science is experimental.	Qualitative description of change to: Diverse methods, Science is not absolutely objective, observations and hypotheses are also important	Intervention facilitated the progressive transitions in teachers' understanding of SM, S, C and E	Question-answer sessions, written exams
4. Donnelly & Argyle (2011)	1 year (36)	TDP physics course	non-int & int	Generic Activities & hands one lab activities + reflection	Most naive was T&L and most informed was E.	Most improve was T&L and least improve was E	Number of teachers at least with adequate view at the end E: -2 I&O: +10 S: +9 T: +2	VNOS-B

Table 6 (continued)

Authors	Duration (n)	Course	Context	Strategies	Pretest views	Posttest views	Results of Effectiveness	Instrument
5. Waibeh & Abd-El-Khalick (2014)	6 weeks, 36 h (19 middle and secondary level)	NOS PD course	non-int & int (highly contextualized)	HPOS case studies, metacognitive strategies, lesson plans	Most naive were O&I and S and most informed was E.	Most improve was T and least improve was SM	T&L: 18 C: +7 Increase (%) of informed views: E: 31.6 I: 52.6 S: 68.4 T: 73.7 T&L: 31.6 SM: 5.3 C: 63.1 S&C: 52.7	VNOS-C
6. Pavez et al., (2016)	120 h distributed in 6 months (8)	Scientific skills and teaching evolution PDP	non-int & int (highly contextualized)	readings, HOS, videos, lesson plans, explicit instruction, hands-on acti & reflection	Most naive was SM and most informed were E and S.	Most improve were T&L and S (eight aspects were studied)	After intervention the number of teachers who held informed views increased for all of the aspects	VNOS-D+
7. Cofré et al., (2017)	120 h distributed in 6 months (31)	NOS & Evolution PDP	non-int & int (highly contextualized)	Readings, HOS, videos, lesson plans, explicit instruction, hands-on acti & reflection	Most naive were SM and T&L and most informed was E.	Most improve was C and the least improve was T&L	Informed views pre and post (%): E: 50→87.5 O&I: 0→50 T&L: 0→25 C: 12.5→87.5 S&C: 37.5→87.5 SM: 12.5→62.5 T: 0→37.5 S: 50→75	VNOS-D+

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