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Promoting Critical Thinking in Higher Education through the Values *and* Knowledge Education (V*a*KE) method

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Word account: Main document and Abstract 5,773 words / Total 5975 words

Promoting Critical Thinking in Higher Education through the Values *and* Knowledge Education (V*a*KE) method

An effective instructional approach for promoting critical thinking is a challenge, not only for Higher Education but also for lower educational levels. In this paper, we argue that Values *and* Knowledge Education (V*a*KE), is an instructional approach, which could be implemented in Higher Education to promote students' critical thinking skills and dispositions. To examine our claim, we implemented the VaKE method in an undergraduate Psychology course in a group of 27 students. During the course, students were asked to suggest a solution in a value-laden situation (dilemma) in which multiple solutions were possible. Structured diaries which followed Facione's definition of critical thinking, including critical thinking skills and dispositions, were used to record students' experiences. A theory-driven content analysis was carried out and results revealed that students experienced the activation of critical thinking skills and dispositions during the different steps of V*a*KE. This study is the first step of our work in progress showing that during the V*a*KE course students activated and implied critical thinking skills and dispositions.

Keywords: Higher Education; Teaching Critical Thinking Dispositions; Teaching Critical Thinking Skills; Values Education; Knowledge Education

Introduction

Contemporary societies urge citizens for active participation that would lead to society's transformation (ten Dam and Volman 2004). This expectation presupposes citizens who would think critically and evaluate the consequences of their choices and actions so that they can make decisions towards the common good. This framework creates a matrix of new demands correlated with critical thinking (CT) and evaluation, which means applying justified values. While recent meta-analyses have indicated that CT can be fostered through education (Abrami et al. 2015; Niu, Behar-Horenstein and Garvan 2013), the development of instructional and teaching methods that could potentially fulfil these newly arising demands is still a challenge for the scholars working in learning and instruction.

Values *and* Knowledge Education (V*a*KE) is a suitable method that could facilitate adult students to acquire the appropriate skills, competencies, and values and thus, for them to meet the expectations for society's transformation (see Pnevmatikos et al. 2016). V*a*KE is a multidisciplinary holistic teaching method that combines values education with knowledge education and meets most of the key elements of transformative learning as described by Mezirow (2000). In the present paper, we present our work in progress, testing whether V*a*KE could also provide opportunities for students to enhance their critical thinking *skills* (CTS) and *dispositions* (CTD).

In the current study, we adopted the Delphi definition of CT, according to which, CT is considered to stand as purposeful, self-regulatory judgement resulting in interpretation, analysis, evaluation and inference. Simultaneously, CT includes the concept of explanation regarding the evidential, conceptual, methodological, criteriological or contextual considerations upon which that judgement is based (Facione, 1990). Additionally, according to Facione (1990, 2000), CT is a two-dimensional construct with a distinction between the competence and the disposition to think critically. *Competency* for critical thinking includes

skills such as interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione 1990). *Disposition* for critical thinking, namely the internal motivation to think critically, includes dispositions for truth-seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness, and cognitive maturity (e.g., Facione 1990, 2000). The competency to do something is a necessary condition for acting accordingly. However, for CT to act in situations, additional prerequisites are required, which are addressed in CTD.

In the following sections, we briefly present an overview of the instructional methods that have already been used for the promotion of CT. Then, we describe the V*a*KE method, and a case study of a V*a*KE implementation in HE showing the method potential to stimulate students' CTS and CTD.

Promoting Critical Thinking through Education

Ennis (1989) proposed a typology to classify the different CT instructional approaches within the general (i.e., CT is taught separately from content), the infusion (i.e., CT is taught explicitly in a specific subject matter), the immersion (i.e., CT is taught implicitly within a particular subject matter) and the mixed approach (i.e., the general approach combined with the infusion or immersion). In their meta-analysis, Abrami et al. (2015) concluded that the mixed approach is the one with the most positive impact on learners.

Furthermore, scholars in HE investigated the impact of multiple instructional strategies on CT, such as the authentic or anchored instruction, mentoring, reflection, problem-based learning, computer-assisted instruction, case studies, hands-on activities, concept mapping, inquiry-based learning and higher order questioning (see Niu et al. 2013 for more information). In their systematic review, Pithers and Soden (2000) suggested that multidisciplinary, inquiry as well as student-centred approaches that enhance learners'

perspective taking, could enhance CT. Contrary to the traditional teaching where the teacher defines the problem to be solved, in the inquiry learning approach, students themselves decide on the problem they are interested in, and they are self-determined to find solutions and check for their appropriateness. Moreover, approaches such as modelling ways of thinking, scaffolding students' understanding and encouraging reflectionon the strengths and weaknesses of an individual's thinking processes facilitate students' meta-cognition and reflection (Pithers and Soden 2000). Finally, it should be mentioned that scholars also highlight the importance of transferring learning across domains for promoting CT (e.g., Halpern 1998).

Values and Knowledge Education Methodology

The scientific theories use general statements, which can be applied either for servinggood or bad purposes. Hence, there is a need for students before entering the labour market- to be able to make evaluations, which is considered to be the highest level of knowledge in the taxonomy of Bloom, Hastings, and Madaus 1971, and the second highest level in the taxonomy of Anderson 2005. To this end, students consider the situational constraints posed by certain values and be prepared for making practical decisions on real problems. The connection of science with controversial social issues has been suggested as a state-of-the-art approach in teaching science for responsible citizenship (e.g. Hofstein, Eilks, and Bybee 2011).

The Values *and* Knowledge Education (V*a*KE) method is an instructional approach that promotes the 'scientific humanism'. Namely, it facitates the acquisition and understanding of conceptual or epistemological knowledge in conjuction with scientific methods and it also sensitises students towards the ethical dimensions of science and technological activities (Pnevmatikos et al. 2016). In other words, the V*a*KE method allows students to use scientific knowledge so that they can make decisions on controversial issues

exercising their argumentation skills, reasoning, critical thinking and decision making to solve real problems with ethical and moral facets.

The V*a*KE method introduces a moral dilemma to the class, namely a conflict where students have to argue in favour of, or against a solution involving moral reasoning and arguments' evaluation. Such moral dilemmas trigger high interest, and the problems can be regarded as authentic. When the dilemmas are constructed in a way that new knowledge is necessary for the moral solution, the students are motivated to find the appropriate information and hence to acquire and implement the relevant knowledge to justify the solution. Students learn to distinguish their beliefs from the evidence and to acknowledge that without knowing about the specific circumstances of a problem, a solution can not be easily suggested.

The introduction of a dilemma allows an inquiry-based, active learning approach starting with an authentic problem of one case study (Niu et al. 2013), which is suitable for the development and practice of thinking skills (Dostál 2015). Thus, in a V*a*KE course, students are progressively engaged in inquiry processes that foster their CTS.

During a V*a*KE course, students seek viable information and argumentation by applying, according to von Glasersfeld (1992), *viability checks*. In other words, they learn to test whether the concepts or arguments are viable (i.e., they serve the purposes they suppose to serve) and also able to survive. Notably, they learn to use various criteria to check the viability of the solutions and the arguments (Patry 2016). For instance, they learn to consider the arguments in favor and against a proposed problem solution and the consequences of the suggested actions. They also learn to test the viability of the arguments in the immediate social environment of the peers, to simulate what would happen if one acts according to a suggestion. Moreover, they learn how to formulate the concepts and arguments in order to communicate them effectively.

Furthermore, through reflections (i.e., examining their thoughts and feelings and reflecting on what values support their arguments), students challenge their value system and may adopt more humanistic values. Simultaneously, they reflect on their initially expressed - usually automatic - responses, which the dual-process theories (Evans 2008) describe as intuitive (i.e. System 1) and learn to rely more on analytical thinking (i.e., System 2 thinking; the rule-based, the rational system).

Students are encouraged to reflect on the process of decision-making as well as to examine whether the preferable solution is plausible. Finally, the method can trigger a commitment to action which together with the reflective thought and self-awareness constitutes the 'critical being' (Barnett, 1997). Hence, V*a*KE offers a chance for authentic and autonomous inquiry-based learning that takes place either individually or collaboratively within a group of participants (e.g., Harding-Smith 1993) and offers students an opportunity for thinking, reflection and transferability of CT in other contexts, and action (Barnett, 1997).

There are narratives indicating that students after experiencing V*a*KE, (i) question more the traditional teaching approaches, (ii) commit less to the naturalistic fallacy as their argumentation evolves (iii) treat sources more critically since they realize that contradicting information can be derived from different means of reference, (iv) consider the opposite views when discussing a problem, and (v) consider the moral issues before their decision making (Pnevmatikos et al., 2016).

Based on the previous evidence, it is plausible to perceive the V*a*KE method as an instructional approach that has the potential to stimulate CTD and foster CTS. Nevertheless, V*a*KE has not been systematically assessed for promoting CT. In the current paper we present our work in progress in which we investigated whether, during students' participation in the V*a*KE-course, they would be able to acknowledge the experience of CTS and CTD that

are described by Facione (1990, 2000). In the following section, we will present the first evidence from the implementation of the V*a*KE method in a Psychology course in HE.

The Course

The course examined motivational theories in education. In particular, students were introduced to contemporary motivation approaches emphasizing their application in educational contexts. It was an elective course at degree level with compulsory attendance. The course duration was thirteen weeks, with 39 hours of lecture during the spring semester of 2018. Twenty-seven undergraduates (2-male) attended the course.

The instructor employed teaching approaches that promote constructivist and autonomous learning. Additionally, students participated in workshops and hands-on activities. V*a*KE was implemented as an instructional approach during a workshop aiming to introduce students to Maslow's theory of motivation –a content which was in accordance with the course curriculum.

Design and Procedure

V*a*KE is a flexible teaching method, which allows teachers to make the necessary adaptations to meet their specific aims. The procedure regarding the implementation of the V*a*KE method consists of at least 12 steps (see Patry et al. 2013 for more information). However, in the current study, a variation of V*a*KE, the V*a*KE-*dis* version was employed, where -*dis* stands for differentiated, individualised and specified reflection (Weyringer 2008). Thus, an additional step for reflection/proflection is introduced (see Table 1). While in a typical V*a*KE unit, moral and content viability checks are employed, V*a*KE-*dis* provides individuals with the opportunity to further engage in self-reflection processes (Weyringer 2008). Self-reflection demands higher-order, analytical, slow and explicit thinking (Evans 2008). Table 1

presents in italics the steps included in a prototypical V*a*KE unit, the additional steps of

V*a*KE-*dis* as well as the actions students were engaged in during each step. These actions

might take place on an individual level (I), in groups (Gs) or in a whole class (C). The V*a*KE

intervention lasted nine teaching hours in a three-week duration, in total.

Insert Table 1 here

To facilitate explicit instruction of CT during the V*a*KE sessions, the instructor used

the step of Preparation and Clarification to introduce the concept of CT to students. Among

others, the definition of Facione was presented alongside with the related CTS and CTD. To

further scaffold explicit instruction on CT elements, the instructor provided a printed copy of

questions that facilitate thinking processes and prompt CT (Paul and Binker 1990) (see Table

2). These questions could be used by students during the 'Exchange information' and

'Reflection/proflection' steps. Thus, it can be assumed that V*a*KE is a mixed approach of

teaching CT according to Ennis' typology (1989) because it allows subject-specific

instruction in CT, combined with the general teaching principles of CT (e.g., the use of

questions that prompt CT).

Insert Table 2 here

Moral dilemmas use hypothetical scenarios that refer to agents who need to make a

decision and choose between two or more, usually conflicting alternatives that concern

competitive values. Usually, the agents endorse a moral violation, namely they avoid the

endorsement of a value to uphold another one promoting the greater good (Valdesolo and

DeSteno 2006). The concepts introduced in a dilemma can be real or plausible, inspired by

real-life situations, which should be meaningful for participants in a moral dilemma

discussion. Although problem-solving and dilemma discussions might share some standard

features such as the inquiry process leading to knowledge acquisition, they differentiate in the

sense that in the latter case, an inquiry is triggered by inadequate moral argumentation due to the lack of information. Therefore, the inability to provide a solution to the conflict described in the dilemma arises.

An essential aspect of the VaKE course implementation is the design of a proper moral dilemma (Pnevmatikos and Patry 2014). An adequate dilemma should fulfil at least three presuppositions. Firstly, the dilemma should employ a set of competitive moral values to trigger students' moral argumentation. Secondly, it should be able to trigger an evidence-based inquiry resulting in the acquisition of the expected knowledge. Thirdly, the dilemma should be personalized, enabling students to identify themselves with the agent in the scenario and thus, achieve participants' engagement. In the present study, students were presented with the following dilemma:

> John is the director of a refugee camp in Greece. Recently, he received a letter from an association of art teachers in Thessaloniki, who offered a visit to the camp in order to provide art courses for refugee children accommodated there. John read the letter and informed the two members of the committee responsible for visitors' authorization in the camp.

> One member of the committee had a severe reaction. He said that the last thing that refugee children needed was art related courses. Additionally, he argued that according to Maslow's pyramid of human needs, individuals need to first satisfy some basic needs and then take care of needs related to the arts. Moreover, he continued by stating that this was a pointless initiative for refugee children and it would be a failure. Eventually, he proposed that if art teachers wished to assist, they would first collect food and clothes and consider arts later.

> The other member of the committee argued that it would be nice to have something in children's curriculum which is free of charge for the camp's budget since the art teacher's association volunteered to provide the courses.

John should now decide how to reply to the letter. What should he respond to the art teachers' association? Should he accept their initiate and invite them to the camp or not?

Structured diaries were employed (DeLongis, Hemphill and Lehman 1992) to collect students' perceived experiences regarding their CT enhancement resulting from their participation in the VaKE course. Specifically, they were asked to note down whether CTS and CTD were activated during the VaKE procedure and to justify their responses by providing the relative explanations. In the end of the course, students 'acted' by preparing the response letter that John would have supposedly sent to the art teachers.

The analysis of the diaries followed the principles of theory-driven content analysis (Patton 2002), as the categories for the analysis deductively emerged from CT theory and particularly from the concept of CT as illustrated by Facione (1990, 2000). After translating the diaries in English, a preliminary reading was carried out, and a theme was defined as the unit of analysis. The themes were related with CTS and CTD according to Facione, and units of analysis were coded on the grounds of how students experienced these CTS and CTD during the VaKE sessions. Sub-skills and sub-dispositions were also used as more specific subcategories of the main categories. The diaries were read several times. Firstly, students' utterances were associated with the main categories already mentioned. Secondly, shorter quotes in English were composed after distinguishing the relevant themes. Then, they were coded with the relevant category code in the analysis table. Students' quotations and the coded-reduced expressions of these quotations were arranged in the analysis table (Table 3). Finally, two raters with experience in Facione's theory for CT classified the quotations; the inter-rater reliability was high ($\kappa = .89$, $p < .05$).

Insert Table 3 here

In their reflections, most of the students mentioned experiences of CTS activation and changes in their CTDs in accordance with our predictions (see Table 1). Below, we will

present students' quotations regarding their perceptions of how CTS and CTD were activated during V*a*KE sessions. Additionally, we will try to relate these perceived experiences with the various V*a*KE steps (see also Table 1). We should stress here that more than one CTSs or CTDs have been activated during each step of V*a*KE.

Interpretation was more likely to be activated during the first step of the V*a*KE process, namely the dilemma introduction. At this step students engaged in (i) understanding the values at stake and the content of the dilemma, (ii) decoding their significance for the dilemma and (iii) identifying the relationship between the content and the values. That is, they found alternative interpretations of the situation. A participant stated:

> *After hearing the dilemma, I realized the values at stake and their importance for the*
> *dilemma storyline.*

(Participant 19)

Although *analysis* could be stimulated during different V*a*KE steps, here the quotation most likely implies that this skill was activated during the step of the first argumentation discussion, where participants identified whether they are in favour of, or against the suggested solutions of the dilemma and express their arguments. Participant 7 indicated:

> *I clarified the two contradicting options that the dilemma protagonist had and tried*
> *to express an argument that corresponded to my point of view.*

(Participant 7)

Inference was experienced during the step of 'Looking for evidence', where students worked in groups and searched for the missing information in available sources such as the internet, books, newspapers. Participant 8 stated:

> *I had to search for information regarding Maslow's theory, which I didn't know but*

while looking for information, I found that the theory was subjected to criticism as research advanced through the years.

(Participant 8)

Evaluation was activated in different steps of V*a*KE, such as the 'First and Second argumentation discussion' or the step of 'Exchanging missing information'. Participant 12 indicated:

We examined ideas related to one of the two suggested choices in a dilemma, we analyzed the most important related arguments, and then each group evaluated the validity of the other team's argument.

(Participant 12)

Explanation was more likely to be activated after the inquiry of evidence, namely in steps of 'Synthesis of information', 'Second argumentation discussion' and 'General synthesis'. Participant 1 suggested:

After having searched for evidence, we had to present our findings and arguments in the group to support our point of view.

(Participant 1)

During the steps of 'Reflection/proflection' participants engaged in self-monitoring and self-correcting steps. Participant 6 suggested:

I was keeping notes of my reasoning and many times my arguments were checked for their viability. So, I enriched some of them and replaced some others.

(Participant 6)

The dilemma triggered participants' curiosity and need for the truth. Therefore, the first step of the method could activate *Truth-seeking*. Participant 5 indicated:

The dilemma made me curious to search whether the information introduced was true

and valid.

<div align="right">(Participant 5)</div>

Open-mindedness was stimulated during the different steps of discussions both within and among the groups. Participant 10 suggested:

> *Different opinions were accepted by group members as long as they were not irrational or out of topic.*

<div align="right">(Participant 10)</div>

Analyticity was triggered in all steps where argumentation can be evidence-based, namely after the step of inquiry and in the steps related to reaching conclusions. Participant 13 stated:

> *After collecting all the required information, and since we compared it with this of the other students, we were able to synthesize it reaching a conclusion.*

<div align="right">(Participant 13)</div>

Systematicity was more likely to be involved in the V*a*KE step of 'looking for evidence' as supported by Participant 2 quote:

> *[…] I tried to be organized through my investigation and search for all the related aspects of the arguments.*

<div align="right">(Participant 2)</div>

Self-Confidence as a CTD was related to evidence-based argumentation by participants. Therefore, it was activated in steps such as 'Synthesis of information', 'Second argumentation discussion' and 'General synthesis'. Participant 18 indicated that:

> *[…] I used evidence-based reasoning to improve my arguments, and that's why I felt more confident about my opinion'.*

<div align="right">(Participant 18)</div>

Inquisitiveness was triggered in the dilemma introduction step, the step of research of information, or even by the discussions that took place both within and among the groups. Participant 2 stated:

> *I heard an argument from a classmate that made me wonder whether it could be scientifically justified. I felt the need to search for additional information and check whether it could be supported with evidence or not.*

(Participant 2)

Cognitive-maturity was another CTD, which was activated during the steps of 'Exchange information', 'Synthesis of information' and 'Second argumentation discussion'. Participant 1 indicated:

> *After the second dilemma discussion and having heard all the arguments, we reached an evidence-based, mutual solution.*

(Participant 1)

The content analysis showed that during the Psychology course with V*a*KE, students captured a variety of experiences that correspond to skills and dispositions which critical thinking scholars described as an integral part of CT. Thus, the current work in progress is the first study showing that by using V*a*KE in HE courses, students have the chance to activate and apply in practice the necessary CTS as well as experience changes in their CTD. Therefore, V*a*KE seems to be a promising method to promote both CTS and CTD. V*a*KE course brought together conflicting perspectives, triggered self-reflection and action based on the personal standpoint that students developed (Barnett, 1997). Finally, students recognized that their understanding is subject to changes when evidence comes up.

Although the implementation of the V*a*KE method showed that students activated all the CTS and CTD across the V*a*KE steps, we are far from arguing that the implementation of

the V*a*KE method results in the enhancement of CT skills and dispositions. Nevertheless, the implementation showed that using V*a*KE method in the HE courses might be a solution to prepare students for the demands of the current societies. Moreover, it opened the path for more rigorous measurements, before and after the implementation, in a broader audience. For this purpose, further studies have been planned, which will include among others, quasi-experimental designs comparing V*a*KE with other approaches expecting to promote CT for measuring the effect size of the method more rigorously.

Conclusions

We showed that V*a*KE could be beneficial in the hands of instructors in HE, who aim to prepare future citizens that think critically, evaluate the implications of their choices and actions considering the common good. The consideration of the common good highlights the correspondence of V*a*KE to the societal need of commitment to emancipation and social justice as perceived by Kant, Habermas, Fairclough or Freire. Moreover, V*a*KE serves as a medium for training students' capacity to question and criticize discourses that contribute to the reproduction of inequalities within the society (Mezirow 2000).

Although the results seem fairly inconclusive, it must be underlined that this is only the first step in examining the effectiveness of the V*a*KE method to enhance CT. In the first step, we used diaries to capture the students' subjective experiences in order to confirm that during a V*a*KE course students experience the activation of the CTS and CTD. The encouraging results motivated us to design the next steps in our research project by using objective measurements. In order to corroboratethe effectiveness of the V*a*KE method to enhance critical thinking in HE, these measurements should provide evidence for (i) the frequency in using the CTS to solve real problems, (ii) the automatic (or not) use of the CTS, (iii) the substantial changes in CTD, and (iv) the students' certainty (or not) both during the

problem-solving procedures and in the produced results when they follow processes that activate their CTS. Hence, the combination of objective and subjective data is necessary forconcluding results about the effectiveness of a method to enhance CTS and CTD in the HE.

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Table 1. Steps of V*a*KE-dis approach

Step		Individual action (I), action in groups (Gs) or class (C)**	Critical Thinking Skills	Critical Thinking Dispositions
0	Preparation and clarification*	Clarification of what the term values means; students' abilities in the working techniques; rules of interaction in the discussion (C)		
1	*Dilemma introduction*	*Understanding dilemma and values at stake (C)*	Interpretation	
2	Reflection/proflection	How am I associated with this dilemma? What opinion do I have? Why do I think this? What values are at stake? (I)	Analysis Explanation	
3	*First decision*	*Who is in favour of, who is against it? (Gs)*	Analysis	
4	*First argumentation discussion*	*Why are you in favour of, why against? Do we agree with each other? (moral viability check) (Gs)*	Analysis Explanation Evaluation Self-regulation	Open-mindedness
5	Reflection/proflection	How am I thinking about the problem now? What opinion do I have now? What questions do I have? (I)	Analysis Explanation	
6	*Exchange experience and missing information*	*Exchange of arguments; what do I need to know more, for a sufficient argumentation? (C)*	Explanation Inference	Truth-seeking Inquisitiveness
7	*Looking for evidence*	*Collect the information, using any source available! (Gs)*	Inference	Truth-seeking

				Inquisitiveness Systematicity
8	*Exchange information*	*Inform the others in your group about your construction; is the information sufficient? (content related viability check) (C)*	Evaluation Self-regulation	Analyticity
9	*Synthesis of information*	*Present your conclusions to the whole class (moral and content related viability check) (C)*	Explanation Self-regulation	Cognitive Maturity Self-confidence Analyticity
10	Reflection/proflection	How am I thinking about the problem now? What opinion do I have now? What questions do I have? (I)	Analysis Explanation	
11	*Second decision*	*Who is in favour of, who is against it? (Gs)*	Analysis	
12	*Second argumentation discussion*	*Why are you in favour of, why against? (moral viability check) (Gs)*	Analysis Evaluation Self-regulation Explanation	Open-mindedness Analyticity Self-confidence
13	*Repeat 5 through 12 if necessary*	*(C) and (Gs)*		
14	Reflection/proflection	How am I thinking about the problem now? What opinion do I have now? What questions do I have? (I)	Analysis Explanation	
15	*General synthesis*	*Closing the sequence capitalizing on the whole process (C)*	Interpretation Inference	Cognitive Maturity

			Explanation	Self-confidence
16	*Generalization*	*Discussion about other but related issues (C) and (Gs)*	All CTS	All CTD

Note: * *Italics* for the steps of the prototypical V*a*KE; ** (I)= Individual action; (Gs)=action in

Groups; (C)= work in Class

Table 2. Questions to prompt Critical Thinking (indicative)

Type of questions and examples
Clarification questions: "What do you mean by your argument?"
Probing assumptions: "What are you assuming?"
Investigating the origins of sources "Where did you get this idea?"
Investigating implications and consequences: "What effect would that have?"
Exploring viewpoints and perspectives: "What would someone who disagrees say?"
Examining reasons and evidence: "Is this a satisfying number of reasons?"

Table 3. Definition categories emerged from content analysis

Skills	Categories
Interpretation (INP)	INP1 Decode the significance of the values and knowledge related to the dilemma INP2 Clarify meaning of values and knowledgerelatedto the dilemma INP3 Clarify arguments after dilemma presentation
Analysis (AN)	AN1 Examine ideas/arguments after the first decision and argumentation discussion AN2 Examine ideas/arguments before reaching a decision/solution to the dilemma AN3 Identify arguments during the first argumentation discussion AN4 Identify in favour of/against arguments AN5 Identify evidence-based reasons and claims behind the arguments for better understanding
Inference (INF)	INF1 Query evidence to support an argument INF2 Search for new knowledge according to the dilemma INF3 Conjecture alternative ideas/opinions of an argument INF4 Draw logically valid/justified conclusions after searching for evidence INF5 Draw reasonably valid/ legitimate conclusions after comparing all information within the different groups
Evaluation (EV)	EV1 Assess the credibility of claims/arguments based on evidence EV2 Group evaluation of arguments

	EV3 Assess the quality and credibility of the information sources
Explanation (EX)	EX1 Present evidence-based arguments in group/ class resulting from the inquiry
	EX2 State evidence-based results after discussion within the group
	EX3 Justification of arguments with evidence
Self-Regulation (SR)	SR1 Monitor and thinking about the consequences of a decision
	SR2 Self-monitoring by keeping personal notes of own way of thinking
	SR3 Self-correct/change an argument after having found evidence against it
	SR4 Self-correct/change an argument after hearing others' arguments
Dispositions	
Truth-Seeking (TS)	TS1 Dilemma provides an opportunity for information search
	TS2 Need for searching information to support my arguments
	TS3 Ask questions to my group/other groups/class to collect information and better understand arguments
	TS4 Searching for valid, scientific information through inquiry
Open-Mindedness (OM)	OM1 Being tolerant and open to divergent views during discussions
	OM2 Give time to understand different opinions
	OM3 Accept only evidence-based arguments to avoid prejudice and personal bias
Analyticity (ANCITY)	ANCITY1 Discussing all evidence-based arguments in the team to solve the dilemma

	ANCITY2 Consider in advance arguments and its counter-arguments on an opinion to make a decision
Systematicity (SY)	SY1 Organise a plan and divide the topics for inquiry
	SY2 Focused inquiry on particular aspects regarding the dilemma
	SY3 Decision making based on evidence resulting from inquiry within the group
Self-Confidence (SC)	SC1 Trust evidence-based opinions and arguments
	SC2 Feeling confident in guiding other group members towards problem-solving
Inquisitiveness (INQ)	INQ1 Being curious to learn new information and examine what discussed in groups
	INQ2 Desire to learn more information triggered by the dilemma
Cognitive-Maturity (CM)	CM1 Taking into consideration others' opinions during group work and class discussion
	CM2 Respect and consider all opinions before reaching a conclusion

Note: The numbers after each acronym, presented in the second column of the Table, are indicators of the concepts included in each category.