The learners' conceptual understanding: Literature review of vapor-pressure lowering and boiling-point elevation

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ABSTRACT

The learners' conceptual understanding has become one of the leading research areas conducted by educational researchers. Both students and current educators should actively work to improve their understanding of alternative conceptions and deepen their conceptual knowledge. One of the essential concepts in chemistry learning is colligative properties. This research is a literature review that discusses vapor-pressure lowering and boiling-point elevation, parts of colligative properties concept. The method used a meta-analysis review that combined the results of multiple studies that required a systematic approach to research of the literature. A preferred reporting items for systematic reviews and meta-analysis or known as PRISMA process was used for study selection. The following literature review was summarized based on various studies from Indonesia, United States of America (USA), Turkey, and Greece. The aims of this review were to provide important details from several previous studies to help researchers obtain complete sources. The findings were also expected to provide the learner with the correct understanding of chemistry, especially in vapor-pressure lowering and boiling-point elevation concepts.

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1. INTRODUCTION

The students' conceptual understanding may vary from person to person, even though they studied the same learning. Students that misapplied the learning concept are often considered to have poor cognitive skills. Despite the fact that students understood the basic knowledge or concept, they are not quite right in applying it to another case [1]–[3]. The accurate conceptual understanding is obtained from basic knowledge formed, improved, added, and revised repeatedly [4]. Aspects closely related to conceptual understanding include knowledge of facts and procedures, connection and transfer of expertise, meaningful learning, and metacognition [5], [6]. Given these aspects, conceptual understanding relies on an ongoing learning process [7], [8]. The ongoing or continuous learning process is the process of learning new skills, abilities, and knowledge continuously. Continuous learning can come from various forms of challenge and evaluation at each stage.

Chemistry is held as one of the demanding study subject for almost every learner: students, teachers, and even researchers [9]. There are two main reasons for these difficulties, first, because it is an abstract topic and second, because words are used for different meanings. The problems are attributable to the lack of students, teachers, and researchers understanding the role of multiple representations. As the essential part of science education, multiple representations aid to build and communicate the understanding of abstract concepts [10]. Knowing chemistry with three levels of representation will remain intact the learners' understanding, even help them grasp how the world operates [11]. However, those complicated reasons for not acknowledging the multiple representations lead learners into an incomplete learning process.

The learners' inadequacy of accepting the learning process ultimately leads to forming alternative conceptions [10]. The alternative conceptions meaning how students think about understanding almost the entire process of the phenomena but cannot wrap up the conclusion of those [1], [3], [12], [13]. Alternative conceptions have preoccupied teachers and educational researchers with revealing students' conceptual understanding. Understanding how to enhance teaching to reduce the adoption of alternative conceptions is thus a challenge for teachers and researchers [14].

Many studies in education discuss the alternative conceptions in chemistry learning, one of which focuses on the content of the solutions [15]–[17]. Some of the conceptual domains in solutions in which most research has been conducted are factors affecting solubility [15], [18]–[21], solutions of electrolyte [22]–[25], colligative properties [15], [26]–[29], and colloids [30]–[32]. The solutions content is challenging to understand because of their sophisticated reasoning and comprehensive phenomenon in operational definitions [26], [27], [29], especially on colligative properties. Research on colligative properties has not been discussed much, compared with other topics (chemical bonding, chemical equilibrium, chemical kinetics, or acids and bases). Therefore, reference studies on the learners' alternative conceptions of colligative properties are still limited.

The colligative properties of solutions are one of the chemical topics in senior high school, with a significant level of misunderstanding [27], [33]. Students' comprehension on the colligative properties of the solution has so far primarily been on the mathematical aspects, even though it has conceptual and algorithmic characteristics [26], [34], whereas there are ways to show colligative properties, experimentally or theoretically [35]. The meticulous scientific learning that combines experiment and theory forges the learners' not only to grasp the comprehension concepts and avoid rote memorization, but also to acquire and construct knowledge. The meaningful learning wields the concept, so that learning can actively engage students to gain direct experience and make the learning worthwhile for them [36]. Not only among students, but the misunderstanding in colligative properties also occurs among teachers [15], [16], [26], [29].

As mentioned previously, there are specific topics in the solutions that chemistry students find harder to acknowledge. One active zone of research on alternative conceptions is colligative properties. This article aims to synthesize students' and prospective teachers' alternative conceptions in various studies at all levels.

2. RESEARCH METHOD

A systematic approach with a meta-analysis research method was used in this literature review. The systematic approach determined whether the learners' conceptual understanding problem was consistent across all studies and discovered which future studies were needed to solve problems. The following process identified any empirical evidence that met the pre-established inclusion criteria to address a research question or assumption [37]–[39]. Since this paper required any information on a topic or evidence to support a hypothesis aimed at conceptual understanding of research data, crucial stages were needed in writing the review [40], [41], they are: i) Identify research questions; ii) Identify relevant studies; iii) Select studies; iv) Table findings; and v) Summarize and report on findings. The analysis followed the preferred reporting items for systematic reviews and meta-analysis or known as PRISMA process for article review and selection, that is shown in Figure 1 [40], [42].

A total of 86 records focusing on solutions topics were retrieved through the database journal search. The other six records were retrieved through learning outcomes of the 1st-3rd grade undergraduate students. From the manual review of the articles' titles and considering the duplication, there were leaving 69 records in the identification step. The screening stage was conducted by reviewing the abstract of solutions' articles. The records that passed the screening process should contain the types of alternative conceptions or misconceptions the research subject owns. The process obtained 57 records regarding alternative conceptions and misconceptions on solutions learning material (factors affecting solubility, solutions of electrolyte, colligative properties, and colloids). In the advanced screening process, 12 records were excluded and 45 records of colligative properties topics were left to the eligibility round. The 45 records selected for the eligibility round were full-text reviewed until obtained the specific topic. After all, the full-text review excluded 32 records and included 13 records of articles based on perceived fit to eligibility criteria.

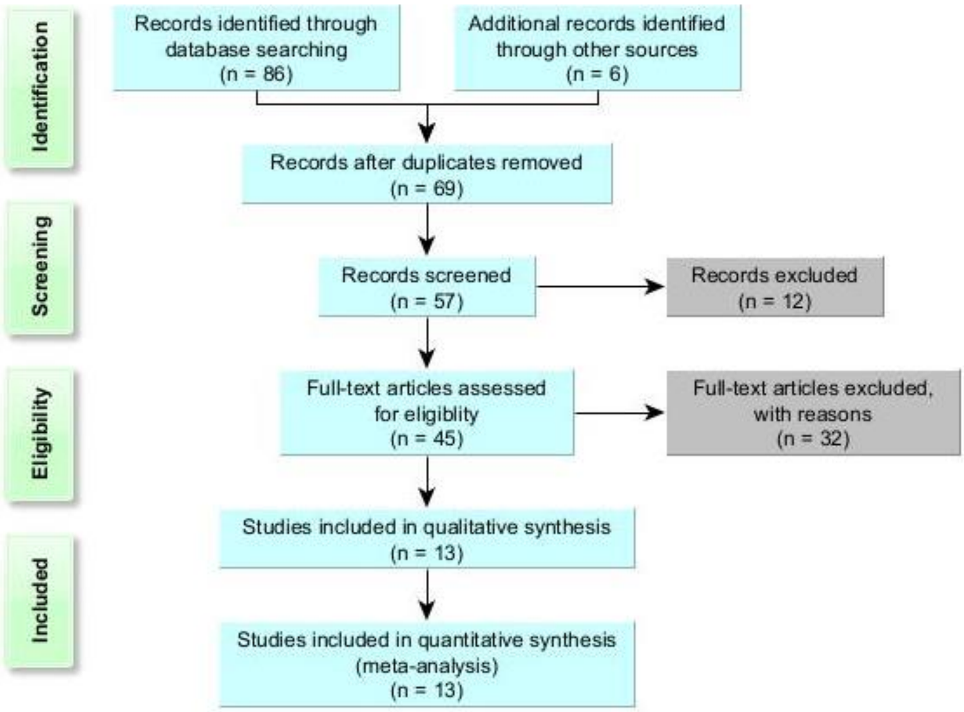

Figure 1. PRISMA flowchart for retrieval process [40], [42]

The final selected articles focus on the learners' conceptual understanding of vapor-pressure lowering and boiling-point elevation. The review may provide insight into unfamiliar research and reveal what has been done well [43]. The paper was produced as a preliminary stage for a further research project on colligative properties, especially in vapor-pressure lowering and boiling-point elevation concepts. Moreover, this can also be a source of further research on alternative conceptions about freezing-point depression and osmotic pressure.

3. RESULTS AND DISCUSSION

3.1. Alternative conceptions about vapor-pressure lowering and boiling-point elevation in high school students

Colligative properties are included in solutions' learning material [44]–[51] and those are vapor-pressure lowering, boiling-point elevation, freezing-point depression, and osmotic pressure. Students and prospective teachers find that the colligative properties of solutions are challenging. This finding is apparent from the 2016 National Examination results, which revealed that about 30-40% of students in Indonesia mastered the colligative nature and scored above the standard of minimum completeness [52]. The contents of colligative properties are abstract, engaging, and relevant to daily life.

The abstract nature of the material made it difficult for students to grasp the concept, resulting in poor students' and prospective teachers' learning outcomes. The learning model's inadequacy or tools might contribute to poor learning outcomes and many alternative conceptions [53]–[55]. Some researchers investigated students' alternative conceptions about colligative properties, especially in vapor-pressure lowering and boiling-point elevation. The alternative conceptions that appear in Indonesian high school students were reported by Fauziah *et al*. [27] and Anugerah *et al*. [56]. The designated study using a digital three-tier multiple-choice diagnostic test expressed that those students had problems because of the electrolyte and nonelectrolyte solutions [27]. Meanwhile, another study found eight alternative conceptions about vapor-pressure lowering and boiling-point elevation. Some students were only familiar with mathematical concepts compared to theoretical ones, so their conceptual understanding was limited. The information was given from the static visualization learning media [53].

Zikovelis and Tsaparlis [28] investigated 11th-grade upper-secondary students in Greece. The work was carried out using a teaching procedure called problem categorization scheme, splitting the subject into two groups (experiment and control class). Some problem categorizations were tabulated, focusing on the solutions' vapor pressure and boiling point. The research's main aim was to develop theories or models that could explain the interaction between problems and their solutions in colligative properties topic. As the results were only preliminary, much remained to be investigated in further research. The summarize of the high school students' alternative conceptions about vapor-pressure lowering and boiling-point elevation is shown in Table 1.

Table 1. The alternative conceptions of vapor-pressure lowering and boiling-point elevation held by high school students

No.	Alternative conceptions	Theoretical conceptions	Sources
1.	Water has an instantaneous vapor pressure when the water evaporates and has a vapor pressure in an open container	A liquid is said to have vapor pressure when the rate of evaporation equals the rate of condensation. Liquid has vapor pressure if it is in a closed container	[53], [57]
2.	Evaporation process needs heat and depends on the temperature of its environment. If the temperature of its environment is higher, evaporation happens. If it is lower, it does not	Evaporation occurs when the partial pressure of water in the air is less than the saturated vapor pressure of the environment and evaporation can occur at room temperature of 100°C. When the environment pressure pushing down, it is difficult for water to escape into the atmosphere as vapor	[57], [58]
3.	Water in a closed container evaporates, and the water vapor formed does not condense	In a closed container, the more liquid molecules evaporate, the greater the chance for molecules in the vapor to condense	[53]
4.	The water molecules in the solution are challenging to evaporate because the solute particles prevent evaporation	The presence of solutes in the solvent increases the intermolecular forces on these particles, so the bonds formed are more robust, and the solution is more difficult to evaporate	[27], [53]
5.	Vapor-pressure lowering of a solution can occur in a solution containing a volatile solute	A solution with a nonvolatile solute has a lower vapor pressure than the vapor pressure of a pure solvent. In contrast, a solution of a volatile solute has a higher vapor pressure than the vapor pressure of a pure solvent	[53]
6.	The harder it is for a liquid to evaporate, the greater its vapor pressure	The more difficult it is for a liquid to evaporate, the fewer molecules of the liquid in the gas phase, so the lower the vapor pressure	[53]
7.	In the process of evaporation, solution turns into air	Evaporation takes place when a liquid substance becomes a gas and escapes into the atmosphere. That liquid substance is solvent, while solute stays	[27], [58]
8.	Evaporation does not occur if boiling does not occur	There are different factors that affect evaporation and boiling procces. Evaporation depends on the pressure comparison of water and environment, meanwhile boiling depends on temperature	[53], [57], [58]
9.	Pure water always boils at 100°C and solution above 100°C	The boiling point of a liquid is reached at a specific temperature when the vapor pressure of the liquid is equal to the vapor pressure of the atmosphere. Thus, pure water, as well as solution, does not always boil at 100°C or above, but can be greater or less than those temperature, depending on the atmospheric pressure	[53]
10.	Boiling-point elevation occurs because the solute blocks the surface of the solution, which leads to an increase of the boiling point of the solution	The presence of solutes in the solvent increases the intermolecular forces on these particles, so the bonds formed are more robust, and the solution is more difficult to boil	[27]
11.	Boiling point elevation can occur in solutions containing volatile solutes	The intermolecular forces in solutions with volatile solutes are weaker than the intermolecular forces in pure solvents. As a result, the solvent molecules in the solution more easily leave the solution, and the boiling point of the solution is lower than the boiling point of the pure solvent	[53]
12.	The rise of the boiling point is explained by the molecular mass of the solution or the addition of a solution with a boiling point higher than its solvent	Boiling-point elevation of a solution depends only on the quantity of dissolved solutes, but not on the chemical identity of the solute	[27], [28]
13.	Both the electrolyte and the electrolyte solution at the same concentration will give the same boiling point	The electrolytes are treated slightly different from the electrolytes. One compound of a nonelectrolyte dissolves in water will form one molecular compound or dissolved particle. However, when one compound of an electrolyte dissolves in water, it normally forms more than one of dissolved particles	[27], [28]

Another research conducted by Kirbulut and Beeth [57] pointed out the concepts of the United States high school students using a phenomenological method with interview. The result indicated that students had inconsistencies in linking theoretical principles related to the concepts with daily phenomena. Related to Coştu *et al*. [58] findings, students in Turkey had been taught the fundamental concepts studied in evaporation. Revealing the students' ideas, predict-discuss-explain-observe-discuss-explain or PDEODE teaching strategy were used. After all, they still did not have a thorough understanding of how they relate to each other, nor did they routinely invoke their understanding of evaporation concepts.

3.2. Alternative conceptions about vapor-pressure lowering and boiling-point elevation in pre-service and prospective chemistry teachers

The latter alternative conceptions occurred in pre-service and prospective chemistry teachers. Yalcin [16] discussed the survey findings of pre-service primary science teachers in Turkey. The research on the phase transition of water revealed that they had an insufficient understanding and common alternative conceptions of vaporization and any effect related to temperature and pressure. The results indicated that pre-service teachers' understanding of the learning material concept was relatively low, and they held some alternative conceptions. None of them used a microscopic representation approach or phase diagram of water to solve the problems or tests.

One predecessor research conducted by Canpolat *et al*. [59] investigated Turkey's prospective teachers' alternative conceptions of vaporization and vapor pressure. The results reflected that the general view of prospective teachers did not gain the concept meaningfully. In the advanced research about boiling-point elevation [26], it was noted that there were significant learning gaps at the conceptual level among prospective teachers. In another study, Tümay [29] investigated their mental model of vapor pressure. Three faulty mental models were found as a result. Those faulty mental models indicated the participants' alternative conceptions of either entities or their properties and relationships in the system. Here is Table 2 that selected and depicted the alternative conceptions held by pre-service and prospective chemistry teachers.

Table 2. The alternative conceptions of vapor-pressure lowering and boiling-point elevation held by pre-service and prospective chemistry teachers

No.	Alternative conceptions	Theoretical conceptions	Sources
1.	A liquid must be heated to vaporize, and the maximum temperature is 100°C	Liquid will vaporize when the partial pressure of water in the air is less than the saturated vapor pressure of the environment. Meanwhile, water will boil when the vapor pressure equals atmospheric pressure, typically at 100°C	[16], [59]
2.	Vaporization starts with boiling or else, liquid boils because of vaporization	Vaporization starts when the partial pressure of water in the air is less than the saturated vapor pressure of the environment. The boiling point of a liquid is reached at a specific temperature when the vapor pressure of the liquid is equal to the vapor pressure of the atmosphere	[59], [60]
3.	In the equilibrium system with a constant volume, the temperature change has no impact on the quantity of liquid or vapor	Liquid-vapor equilibrium in a closed container tends to reestablish at a certain point, and the amount of vapor varies according to volume or temperature	[16], [29]
4.	When the water temperature increases in a closed container, all the liquid water will vaporize	When the system reaches equilibrium, the liquid water and vapor phases will evaporate and condense at the equal rate	[16]
5.	The water's state transition depends only on the temperature	Pressure in the system also affects the phase transition of water	[16], [60]
6.	The vapor pressure of a liquid is a function of the total number of vapor particles	Vapor pressure of the liquid is directly dependent on the number of particles per unit volume	[29], [59]
7.	The vapor pressure is excelled only to the surface of the liquid	Vapor pressure acts in all directions, not only downwards or upwards	[29], [59]
8.	The vapor pressure depends on the amount of the liquid	A liquid's vapor pressure never changes in order to the amount of the liquid. The vaporization depends on saturated vapor pressure	[59]
9.	Vapor-pressure lowering of electrolyte solution greater than nonelectrolyte solution because there are more particles of electrolyte that covers the surface of solution	Vapor-pressure lowering of a solution depends only on the quantity of dissolved solutes, but not on the chemical identity of the solute. The presence of solutes in the solvent increases the intermolecular forces on these particles, so the bonds formed are more robust, and the solution is more difficult to evaporate	[55]
10.	The boiling-point elevation occurs because of the interaction between water and salt particles	The boiling-point elevation occurs between every particle in the solution: solute-solute particle, solute-solvent particle, solvent-solvent particle	[26]

Table 2. The alternative conceptions of vapor-pressure lowering and boiling-point elevation held by pre-service and prospective chemistry teachers (*continued*)

No.	Alternative conceptions	Theoretical conceptions	Sources
11.	The change in boiling temperature of higher-density liquids would be larger than that of lower-density liquids	The boiling temperature of liquids stays constant and does not change. The change only occurs in the solution	[26]
12.	The boiling temperature is not constant as boiling point of water is lower than salt	The boiling temperature of the water is constant at its boiling point under constant pressure. Meanwhile, salt is solid, so it has a melting point, not a boiling point	[26]
13.	The boiling temperature is not constant because part of the heat will be devoted to salt	Adding the solute to the solvent is only one factor in the temperature changes. The solvent and solute do not boil independently from each other	[26]
14.	The boiling-point elevation of the electrolyte and nonelectrolyte solution is different because of the chemical characteristic of the substances	The electrolytes are treated slightly different from the nonelectrolytes. One compound of a nonelectrolyte dissolves in water will form one molecular compound or dissolved particle. However, when one compound of an electrolyte dissolves in water, it typically forms more than one of the dissolved particles	[55]
15.	Molality is used in calculating boiling-point elevation, not molarity. It is because the solvent's mass is used as the amount of substance, not the volume of the solvent	Molality is used, not molarity because molality is independent of temperature; in contrast, molarity is not. To determine the boiling point elevation, the amount of the substance must not change at any temperature change	[55]
16.	Salt and sugar would create impurities in solution, but the molecular dissolution of sugar cannot be the reason for increasing the boiling point	Salt solution is electrolyte, sugar solution is nonelectrolyte. Both electrolyte and nonelectrolyte solutions affect the colligative properties	[61]
17.	Acid and base solutions do not show colligative properties	Acid and base solutions are kind of electrolyte and always affect the colligative properties, even just a slight	[61]

That was consistent with Sinaga *et al.* [11] findings. The students' acknowledgement at the microscopic or molecular level in electrolyte and nonelectrolyte solutions of the colligative properties was the weakest compared to the other representation levels. The fact was that while they were getting close to the answer, they still could not fully acknowledge the concept. The research using dialogic teaching showed that students might not be able to transfer the conceptual understanding of the textbook to a specific case of boiling point and pressure [60]. Others stated that a limited amount of literature had been found in which relevant literature on colligative properties [61]. In reviewing the literature, as mentioned earlier, there were many alternative conceptions that existed.

3.3. Teaching implications in vapor-pressure lowering and boiling-point elevation

In almost all science majors, colligative properties of solutions were one topic in an introductory chemistry course. Within the course of implementation, the learners' alternative conceptions of vapor-pressure lowering and boiling-point elevation were often found. The summarized alternative conceptions included understanding the concept of vapor pressure correlated to the molecular illustrations of the evaporation and condensation, boiling point and its process, the effect of electrolyte and nonelectrolyte materials on the solvent, and molecular forces between particles of the solutions. Since the concept of colligative properties was built upon the fundamental principles of the particulate nature of matter, this understanding of behavior at any level (macroscopic, submicroscopic, algorithmic) appeared important in understanding subsequent concepts in chemistry.

A lot of studies revealed students had struggled in understanding colligative properties, yet still held several alternative conceptions, although they had learned the particulate nature of matter concepts. These alternative conceptions seemed to resist attempts to change them over time, despite heightened education in chemistry. Students passed from one year to another without completely understanding the fundamental concepts, especially in vapor-pressure lowering and boiling-point elevation. Rectifying the learners' alternative conceptions was a crucial step to take, not only for students, but also for pre-service and prospective teachers. Being aware of and concern for alternative conceptions in the topic allowed researchers to anticipate some of the challenges for not only students, but also teachers may face.

After the learners' alternative conceptions on vapor-pressure lowering and boiling-point elevation in the reported literature were investigated and presented, a couple of suggestions for teaching were made. For each result found, the recommended learning can be specifically different. Indonesian high school students experienced difficulties due to electrolyte, nonelectrolyte solution, and solution mixture [27]. From the interviews, students' alternative conceptions tended to be included in the low category. The average percentage of students' alternative conceptions in vapor-pressure lowering got 8.64% and 8.82% in boiling-point elevation content. The study suggested that teachers needed to consider the possibility of students' mistakes to anticipate the case.

Another research said that static visualization media was an effective way to eliminate students' alternative conceptions [53]. Through the media, alternative conceptions reduction in students was about 73.1% in vapor-pressure lowering and 75.0% in boiling-point elevation topic. Both contents above were considered as a high category. On the other hand, students' persistence of alternative conceptions was categorized as low, with 11.0%. Using static visualization media that was arranged coherently, starting from the basic concept to the next concept, made it easier for students to understand the phenomenon of colligative properties of solutions, which are primarily abstract.

There was a recommendation from research on United States high school students. The interview data highlighted students' difficulties in explaining the concepts of boiling and vapor pressure. Some practical implications were that students should be expected to link concepts at multiple representation levels and to present them into everyday phenomena. The study propounded that metaconceptual teaching activities, including mind mapping, journaling, and discussion inside and outside class, were helpful for students to connect the concepts [57]. In Greece, problem solving teaching method can be useful for categorizing each content issue involved. From problem categorizing, there was an outcome of a knowledge base that contributed to successful problem solving for students' cognitive, affective, and psychomotor. These students constructed on their mental representations of problems given, resulting in the proper categorization [28].

Another teaching strategy called PDEODE was implemented in a chemistry class in Turkey [58]. There were three types of items to assess students' conceptual change during learning, there were multiple-choice test items, two-tier diagnostic test items, and open-ended test items. The results showed that the PDEODE learning activities provided students with conceptual change towards more scientific ones. That teaching strategy effectively and straightforwardly reduced the number of alternative conceptions students carried about evaporation. However, no statistically significant differences proved that the teaching method enabled students to reserve their conceptual understanding in long-term memory.

In contrast to research on students, research conducted on pre-service and prospective chemistry teachers had a more profound and broader application pattern. Pre-service and prospective chemistry teachers were the spearhead of education; therefore, their conceptual understanding must be correct in detail. Therefore, improvements to alternative conceptions and misconceptions must also be carried out broader and more in-depth, depending on their difficulties.

The results of one study revealed that Turkish prospective teachers had some insufficient conceptual understanding and alternative conceptions of vaporization and the effect of pressure and temperature on the water's phase transition [16]. Only 7.4% of the total students clearly understood about those effects on the phase transition in water. About 45.4% have misunderstandings and rather significant alternative conceptions, referring that students have difficulty understanding the concepts. Students indicated they achieved algorithmic understanding rather than mastered the microscopic approach to interpreting the questions. They need to understand fundamental chemical ideas before teaching progressive ideas. The study findings provide valuable knowledge for researchers and teacher trainers.

Another study's conclusion from Turkey described prospective chemistry teachers' mental model of vapor pressure [29]. The study results showed that only 14.1% of participants had successfully built a scientific model to explain the vapor pressure of liquids under various conditions. As previously described, there are three faulty mental models of vapor pressure possessed by most of the participants. Microscopic illustrations or animations as a support of practical experiences perchance the challenges and information of learners' mental model. Other than practical experience, engaging learners in the argument was recommended to help them learn about their and others' mental models. The identified mental models had devised the more effective pedagogical approach that encouraged the scientific models' creation.

The prior results of the study about misconceptions of vaporization and vapor pressure [59] and colligative properties [26] of Turkish prospective chemistry teachers reflected the general view of their preconceptions weaknesses. Preconceptions had influenced the interpretation and understanding of new knowledge. Teachers should increase the opportunity to replace misconceptions with a clear understanding of scientific concepts by linking existing and emerging teacher knowledge. Furthermore, misconceptions may come from the textbook. To avoid common misconceptions, textbook writers should give more consideration to the detailed content. More suggestions that the textbook should come up with molecular or microscopic representation and in-depth conceptual exercises to provide learners in understanding the phenomena of colligative properties.

The learning strategy called the dialogic teaching interventions successfully fixed most conceptual difficulties, including several alternative conceptions [60]. Dialogic teaching interventions might be a part of educators' learning because of the ease of conceptual change procedures, even in highly misunderstood content. Dialogic interventions treated conceptual difficulties in moving the knowledge further. The suggestions were able to facilitate procedure conceptual change, but it needed to be effectively planned in-class learning. Furthermore, the alternative conceptions could be converted into correct concept knowledge by shifting patterns using a metacognitive learning strategy [55]. Skills in planning, monitoring, and evaluation which were entailed in a metacognitive learning strategy play a role in shifting the alternative conceptions into the more accurate conceptual understanding of colligative properties of the solutions.

The teaching implications that have been described are proven to vary, depending on the country's cultural conditions, the educational environment's state, the type of learning material or topic, the learning methods used, the psychology of students, and several other things. One common thing from the vapor-pressure lowering and boiling-point elevation topic is that alternative conceptions in learners still exist if the learning resources and teaching methods are not appropriate. Every learner, whether researchers, lecturers, teachers, pre-service teachers, prospective chemistry teachers, or students, continues to learn so that the teaching implications can bring positive changes over time.

4. CONCLUSION

Based on the several kinds of literature that have been conducted, it can be concluded that: i) Literature review sources of vapor-pressure lowering and boiling-point elevation are obtained from various countries, including Indonesia, Greece, Turkey, and the United States; ii) There are 13 alternative conceptions formed by high school students; iii) There are 17 alternative conceptions created by pre-service and prospective chemistry teachers; and iv) The teaching implications that have been described are different, depending on many things. This paper is a preliminary round and further research is needed to assess the use of teaching implications for alternative conceptions. Further research can be about the research of alternative conceptions about freezing-point depression and osmotic pressure topics or provide the accurate understanding of the learners related to colligative properties.

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