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Making the Learning of Acid-Base Concepts More Relevant - A Research Study

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Abstract This study examines how learning acid-base concepts can be made more relevant for students. It analyzes how the concepts learned in chemistry by tenth graders are aligned with their everyday lives. Two approaches to teaching are compared: the *Low Relevance Approach (LRA)* and the *High Relevance Approach (HRA).* The *HRA* approach emphasizes learning how chemistry materials are relevant to students' daily life. The subject taught was "acids and bases". Following the intervention program, a perception-type motivation and satisfaction questionnaire was administered to the students in order to determine the effect that the 'relevant experiential' teaching style had on students' attitudes towards chemistry, regarding their motivation for and satisfaction when studying chemistry, and on their academic achievements in the chemistry. Based on the assessment of students' cognitive and scholastic performance, it is clear that relevance-oriented experiments in chemistry significantly contribute to these learning variables.

Keywords Introductory, Laboratory Instruction, Hands-On Learning, Pedagogy, Acids / Bases Topics

1. Introduction

Bratz [1] wrote that no evidence exists to support the hypothesis that instruction designed in response to students' learning styles can improve achievement. On the other hand, Towns [2] described how Kolb's learning styles were particularly well suited to learning in the chemistry laboratory. Pashler and colleagues [3] reported that learning is optimized when the instruction matches the learner's preferences and abilities.

Many studies have presented a gloomy picture with respect to the learning styles of science, especially at the secondary school level. A key claim is that science education - particularly in physics and chemistry - remains unpopular among students. Several of these studies [4-6] infer that students are insufficiently interested in chemistry and/or not motivated to learn chemistry concepts and topics. Learners were frequently found to perceive chemistry as "irrelevant" both for themselves and for the society in which they live. [5, 7, 8] Science teachers in general, and chemistry teachers in particular, are urged to make learning science (chemistry in our case) "more relevant" in order to better motivate their students and interest them in learning chemistry. [9-12] However, it may be unclear to instructors what exactly is meant by "making science learning more relevant". The connections (or differences) among terms such as relevance, interest, and motivation may need clarification. Recently, Stuckey et al. [13] published a review and Eilks and Hofstein edited a book on the issue of relevance regarding the teaching and learning of chemistry in which the concept of relevance is analyzed and a schematic framework for relevance in science learning is suggested [14, 15].

Three dimensions for relevance in science education are proposed*: individual, societal,* and *vocational* [13]. Here is a short version of these characteristics:

- The *individual dimension:* This focuses on matching the subject matter to the learners' curiosity and interests, providing students with necessary and useful skills for coping with their everyday lives today and in the future, and contributing to pupils' development of intellectual skills.
- The *societal dimension*: This focuses on preparing pupils for self-determination and on achieving a responsibly led life in society by understanding the interdependence and interaction of science and society, and by developing skills for societal participation and competencies in order to contribute to society's sustainable development.
- The *vocational dimension*: This focuses on offering orientation for future professions and careers, preparing for further academic or vocational training, and opening up formal career chances (e.g., by having sufficient coursework and achievements to enter into institutions

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of higher education).

These dimensions are not fully complementary or dichotomized. They are interrelated and partially overlap. For example, either career orientation can match personal curiosity or it can answer a demand for more scientists and engineers in the future. The latter is directly linked to the idea of the prosperous and sustainable development of society.

The model [14], which has been slightly modified, illustrating the different dimensions of the relevance of science education (Figure 1); it can easily be adapted and interpreted also for the domain of chemistry education, since it constitutes part of science education in general.

In general, it is agreed that in order to make learning more relevant both to the students' personal life as well as to the society in which they live it is important to change both the content as well as the pedagogy of the teaching of chemistry [13, 14]. Several researchers suggested both learning modules as well as appropriate pedagogies in an attempt to make the learning of chemistry more relevant and thus more interesting and motivating. More specifically, they combined the development of teaching units, and implemented them in schools, to advance the professional development of chemistry teachers. [16-20]

The 1980s was an era in which context-based chemistry guided many chemistry curricula. Garfoth [21] wrote that: "Few courses draw on the experiences that pupil[s] bring from their everyday lives and this is much truer in chemistry than other two (physics and biology) sciences."

2. The Study

As mentioned before, chemistry education in secondary school is often seen as divorced from real life. It usually takes place in a school classroom or laboratory setting using abstract concepts and unfamiliar language (the language of chemistry). As a result, students do not see the relevance, interest, and/or importance of their everyday life outside of school or their future role in society. [22] Thus, chemistry topics taught in schools should help students understand and use basic chemical concepts as well as relate these concepts to real world issues. In addition, the lessons should demonstrate how chemistry is used for understanding and controlling issues such as food chemistry, climate change (acid rain) energy consumption, and others.

The current study's main objective was to seek, understand, and propose methods that would enable chemistry teachers to acquire tools for teaching the sciences in general and chemistry in particular (specifically acids and bases) in a way that would enhance students' curiosity and enable them to associate the study materials with their own personal lives and to the society in which they operate.

In the following study we adapted two pedagogical approaches for teaching chemistry concepts (see Figure 2) *the Low Relevance Approach (LRA)* (Traditional Process) that is mainly based on a conceptual approach and often ends there, and *the High Relevance Approach (HRA)* (Alternative Process) that is mainly based on students' experiences in their lives, for example, materials used in kitchen chemistry, food chemistry, and others, These two approaches were statistically compared.

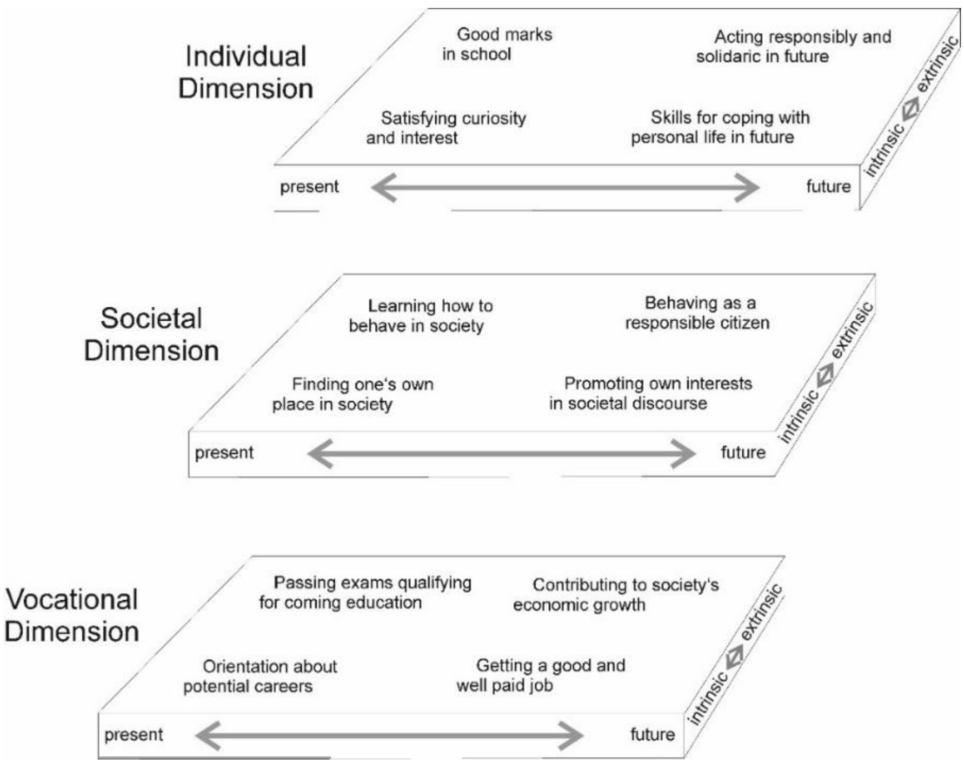

Figure 1. A model of the three dimensions of relevance with examples of aspects in both the present-future and the intrinsic-extrinsic range (Reprinted with permission from ref. 14, © *2015 Sense Publishers*: Rotterdam)

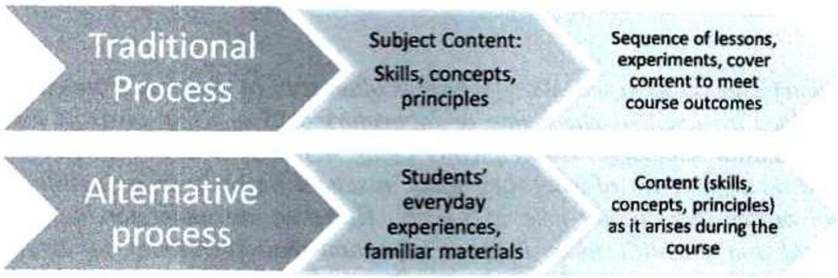

Figure 2. Two curriculum approaches in chemistry (Reprinted with permission from ref. 22, © *2015 Sense Publishers*: Rotterdam)

One of the reasons mentioned quite frequently is that learners do not perceive chemistry and chemistry education as relevant both for themselves and for the society in which they live. The present research suggests that chemistry teachers must make chemistry education "more relevant" in order to increase student motivation and satisfaction and improve their attitudes towards chemistry and its study.

3. Methodology

The Low Relevance Approach (LRA)

One of the most key concept in teaching chemistry in school is the acid-base topic. [23] In accordance with this method, the student learns about acids and bases in a method sequence of lessons, activities, experiments, and cover content to meet course outcomes. Here the materials used in the experiments are not from daily life, such as HNO_3, H_2SO_4, NaOH, and HCl.

Students learn about titration between an acid (HCl) and a base (NaOH) when the indicator is Phenolphthalein or litmus paper, materials unfamiliar to them from their experience in everyday life. Additionally, students learn about the *p*H scale, different types of acids and bases, and the reactions between them; however, the students encounter none of these topics in their daily life. Students also learn about the preparation of acids and bases caused by the reaction between different chemical oxides and water; here too, none of these materials are known from their everyday life (more details about the lessons, activities and experiments you can find in the supporting information).

The *LRA* is abstract teaching; it is traditional process [22], which contain sequence of lessons, experiments, cover content to meet course outcomes (Fig. 2, Fig. 3). This method does not support the *individual*, *social* and *vocational* dimension according to the model (Fig. 1) [14] described by Stucky et al. [13]

The High Relevance Approach (HRA)

In our everyday lives we use various materials for different purposes, which we usually take for granted and do not consider what life would be like without them. One interesting exercise is to get students to think what their day would be like without any products produced by chemistry. These students study the acid-base concept in a manner relevant to their everyday lives, using materials such as vinegar as an acid and baking soda solution as a base, materials that are used every day or that represent the chemistry of everyday objects. The indicator that is used to identify the acids and bases and the subject of titration is red cabbage juice, which is derived from red cabbage salad, a popular salad in Israel. It should be emphasized here that the student uses materials with which they are familiar, especially from the kitchen [24, 25]. Here in Israel, the most popular and well-known salad is red cabbage salad. There is hardly a meal in Israel that does not contain this salad, and on the other hand, it is one of the main ingredients in the falafel sandwich (actually pita), which is considered the Israeli national food. In addition, hardly any Israeli kitchen does not contain white vinegar, baking soda, and lemon juice, which are added to the red cabbage salad.

The students also learn about acid production using as an example the acid rain that is very common in the Haifa Bay region, which has a large number of chemical plants. Sulfur dioxide - SO_2 – is emitted by the refineries at Gadiv, Nadiv, Carmel Olefins, and Nesher. It is emitted because of the burning of fuel oil with high sulfur content. Until 2014, it was also emitted from the electricity company's chimneys.Chemicals and fertilizers such as nitrogen oxides - NO_x - are emitted from Haifa during the process of producing nitric acid (HNO_3).

Students build their own *p*H scale from the obvious visible changes using the red cabbage juice along with acids and bases from their daily life. Preparing an indicator requires using extracts of red cabbage. In this activity, the social side of the activity is strengthened when the students need to cut the red cabbage and then discover that their hands are stained. They must collaborate to decide how to prepare an indicator solution from it and they discover that the color varies depending on the acidic/basic solution. The relevant part of this method is that students collaborate and think together to create an indicator from red cabbage, which is familiar to every resident in Israel (more details about the lessons, activities and experiments you can find in the supporting information).

The *HRA* is alternative process [22], which contain sequence of lessons, experiments using familiar materials and focus in the students' everyday experiences (Fig. 2, Fig. 3). This method supports the *individual*, *social* and *vocational* dimension according to the model (Fig. 1) [14] described by Stucky et al. [13]

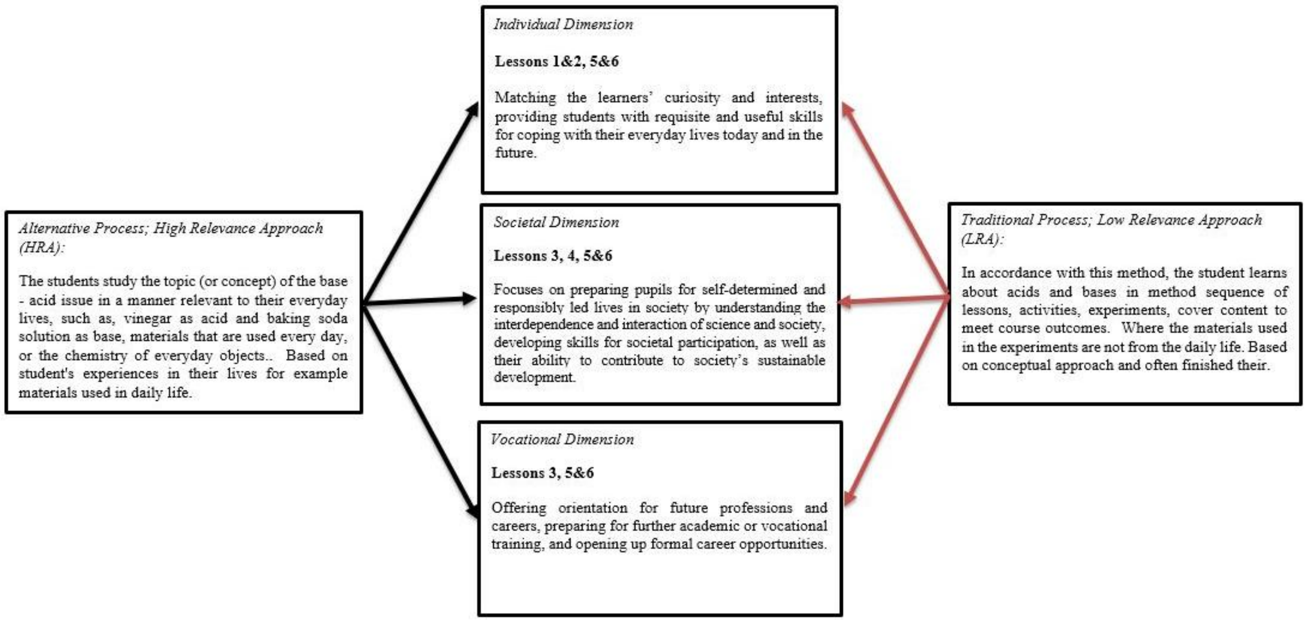

Figure 3. Comparison between the two methods; *HRA*, which support, *individual, social* and *vocational* dimension; and *LRA*, which does not supports these dimensions

Research population

The research population consisted of 120 high-school science students. For the present study, two 10th grade classes in each of two different secondary schools in Israel were chosen. The students in these classes were heterogeneous regarding their socio-economic background and their academic achievements. In each school, one of the chosen classes was defined as the experimental group and the other as the control group. Thus, there were in all, two experimental classes in which the acid-base topic was taught using the *HRA* according to an intervention plan, and two control classes in which the subject was taught using the *LRA*. In all, 63 students (males and females) from School A (52.5%) participated in the study, of whom 32 students (50.8%) were in the experimental class and 31 (49.2%) were in the control class; in School B 57 students participated (47.5%), 29 in the experimental class (50.9%) and 28 in the control class (49.1%).

4. Assessment Measures

The research tool consists of a structured questionnaire with three parts.

Part One*: Structured questionnaire for measuring students' level of motivation*

For use with the students in this study, a questionnaire of 30 statements was developed from Glynn & Koballa's Science Motivation Questionnaire [26]. This questionnaire has a reliability (internal consistency) of $\alpha = 0.93$ [26] and tests six different aspects of motivation with statements describing situations and behaviors of students. In order to adapt the questionnaire to be used in the Arabic schools, it was translated to Arabic and the content was validated by a group of faculty members in the Arabic College, both for the language as well as for the content.

The variable of "motivation" was determined by calculating the mean of participants' responses to the 30 items. Every student received a motivation score ranging between 1 and 5; the higher the score, the greater the motivation, and *vice versa*. The motivation questionnaire's reliability was checked by means of an internal consistency test using Cronbach's alpha reliability coefficient. The result, $\alpha = 0.89$, indicates high reliability.

Part Two: *Structured questionnaire for measuring student attitudes towards the sciences*

The questionnaire was adapted from (translated to Arabic from Hebrew) Abadi & Kashtan [27] and consists of 22 statements that measure students' attitudes towards the sciences that include depicting situations, personal feelings, and beliefs. All students were asked to report the extent to which they agree with each of the beliefs and concepts in the questionnaire, using a four-item Likert scale: 1 – do not agree at all (oppose); 2 – disagree; 3 – agree; 4 – very much agree. The reliability coefficient was $\alpha = 0.83$.

Part Three*: Open questions related to students' perceptions regarding "relevance"*

In addition to the above-described quantitative measures, the students also underwent a structured interview questionnaire in order to back up the quantitative findings and to shed more light on the research topic.

This questionnaire consists of six open-end questions in which the students are requested to describe their attitudes, opinions, and feelings towards their participation in the intervention program and towards instruction of science by means of the relevance approach. The answers were analyzed using content analysis and cross-checked with the quantitative findings. Several members of the college staff validated the content to ensure the accuracy and validity of its translation into Arabic (from English and Hebrew).

5. Research Design and Procedure

This research is a 'pre-post intervention' and an 'experimental-control'-oriented study.

Research Sample

The study population consists of two groups, each composed of tenth-grade classes. The two groups were nearly identical regarding the features relevant for the study. The questionnaires were administered to the two groups at the beginning of the study (intervention). Then one group was defined as the control group, which would be taught using the *LRA*, and the other was defined as the experimental group, which would be taught using the *HRA* in an intervention program.

In order to test the independent variable and determine whether it underwent any change, the attitude and motivation questionnaires were once again given to both groups and data on them were collected by means of the concluding questionnaire. A sample group of students was then selected to fill in an open-ended questionnaire.

The data were analyzed in accordance with the principles of quantitative research. In order to test for variance within and between the groups regarding motivation, an F-test for variance was carried out before and after the experiment; in order to test for variance within and between the groups regarding the variable of satisfaction before and after the experiment, a *t*-test was conducted on two independent samples, to determine whether the variance between the (experimental and control) groups was significant. In addition, a Pearson correlation coefficient was used to determine whether and how the variable of achievement correlated with the variables of attitudes and motivation.

6. Results

The hypothesis that teaching topics in chemistry (acids and bases) by using the relevance method (*HRA*) brings about an improvement in students' attitudes in comparison with students who were instructed using the *LRA* was tested in three stages. The first stage took place before the intervention program was implemented; it involved testing for differences in attitude towards chemistry and its study among the students in the experimental (*HRA*) and the control groups (*LRA*), in order to determine both groups' initial stage before one of them participated in the intervention program. The difference between the two groups was determined by means of a *t*-test for two independent samples.

Table 1. Means and standard deviations for attitudes towards chemistry and its study among students of the experimental (*HRA*) and the control (*LRA*) groups before the intervention program, and the t value of the difference between them

Group	N	Mean (1-4)	Standard deviation	*t*
Experimental (*HRA*)	61	2.08	0.11	NS
Control (*LRA*)	59	2.10	0.10	

The findings presented in Table 1 reveal non-significant differences in the attitudes of the two groups before implementing the intervention program. In other words, the attitudes of students in both the experimental (*HRA*) and control (*LRA*) groups before the intervention program were similar.

In the second stage, the difference in the attitudes of the experimental group (*HRA*) before and after implementing the intervention program was tested. The difference was determined by means of a *t*-test for two independent samples.

Table 2. Means and standard deviations for attitudes towards chemistry and its study among students in the experimental group (*HRA*) before and after the intervention program, and the *t* value of the difference

Group	N	Mean (1-4)	Standard deviation	*t*
Before	61	2.08	0.11	
After	61	3.18	0.35	23.68***
*** *p*<.001				

The findings, presented in Table 2, reveal a significant difference between the attitudes towards chemistry and its study among students in the experimental group (*HRA*) before and after the intervention program. The mean of students' attitudes after the intervention is higher than the mean before the intervention. In other words, the attitudes towards chemistry and its study among students who participated in the intervention program improved.

In the third stage, the difference in the attitudes of the experimental group (*HRA*) after implementing the intervention program was compared to the attitudes of the control group (*LRA*). The difference between the two groups was determined by means of a *t*-test for two independent samples.

Table 3. Means and standard deviations for attitudes towards chemistry and its study among students in both groups after the intervention program, and the t value of the difference

Group	N	Mean (1-4)	Standard deviation	*t*
Experimental (*HRA*)	61	3.18	0.35	
Control (*LRA*)	59	2.09	0.10	17.7***
*** *p*<.001				

The findings, presented in Table 3, reveal a significant difference in the attitudes of students in the two groups after the intervention. The mean attitude of the experimental group (*HRA*) after the intervention program is higher than the mean in the control group (*LRA*) after the intervention. In other words, the previously non-existence difference in attitude between the two groups became apparent. The intervention program in which chemistry was taught to the experimental group (*HRA*) using the relevance approach brought about an improvement in students' attitudes towards chemistry and its study.

Table 4. Means and standard deviations for motivation for and satisfaction with the study of science among students in the experimental (*HRA*) and the control (*LRA*) groups before the intervention program, and the *t* value of the difference between them

Group	N	Mean (1-5)	Standard deviation	*t*
Experimental (*HRA*)	61	2.31	0.41	
Control (*LRA*)	59	2.47	0.42	1.62 NS

The findings, presented in Table 4, do not show a statistically significant difference in the motivation and satisfaction of the two groups before implementing the intervention program. In other words, the motivation and satisfaction of students in both the experimental (*HRA*) and control (*LRA*) groups before the intervention program were similar.

In the second stage the differences in the motivation and satisfaction of the experimental group (*HRA*) before and after implementing the intervention program was tested. The difference was determined by means of a *t*-test for two independent samples.

Table 5. Means and standard deviations for motivation for and satisfaction with studying chemistry among students in the experimental group (*HRA*) before and after the intervention program, and the *t* value of the difference

Group	N	Mean (1-5)	Standard deviation	*t*
Before	61	2.**31**	0.41	
After	61	4.07	0.19	30.40***
*** *p*<.001				

The findings, presented in Table 5, reveal a significant difference between the level of motivation and satisfaction in studying chemistry among students in the experimental group (*HRA*) before and after the intervention program. The mean of students' motivation and satisfaction after the intervention is higher than the mean before the intervention. In other words, the motivation and satisfaction among students who participated in the intervention program improved.

Table 6. Means and standard deviations for motivation for and satisfaction with studying chemistry among students of both groups after the intervention program, and the *t* value of the difference

Group	N	Mean (1-5)	Standard deviation	*T*
Experimental (*HRA*)	61	4.07	0.19	42.33***
Control (*LRA*)	59	2.51	0.46	
*** p<0.00				

In the third stage, the difference in the motivation and satisfaction of the experimental group (*HRA*) after implementing the intervention program was compared to those of the control group (*LRA*). The difference between the two groups was determined by means of a *t*-test for two independent samples.

The findings, presented in Table 6 above, show a significant difference in the levels of motivation and satisfaction among students in the two groups after the intervention. The mean motivation and satisfaction of the experimental group (*HRA*) after the intervention program is higher than the mean in the control group (*LRA*) after the course. In other words, a previously non-existent difference in motivation and satisfaction between the two groups became apparent. The intervention program in which science was taught to the experimental group (*HRA*) using the relevance approach brought about an improvement in students' motivation for and satisfaction with the study of science.

Table 7. Means and standard deviations for academic achievement in chemistry among students in the experimental (*HRA*) and the control groups (*LRA*) before the intervention program, and the t value of the difference between them

Group	N	Mean (1-100)	Standard deviation	t
Experimental (*HRA*)	61	80.38	10.33	
Control (*LRA*)	59	78.92	11.40	0.74 NS

The findings, presented in Table 7, do not show a statistically significant difference in academic achievements in chemistry by the two groups before implementing the intervention program. In other words, the motivation and satisfaction of students in both the experimental (*HRA*) and control (*LRA*) groups before the intervention program were similar.

In the second stage the differences in the academic achievement of the experimental group (*HRA*) before and after implementing the intervention program was tested. The difference was determined by means of a *t*-test for two independent samples.

Table 8. Means and standard deviations for motivation for and satisfaction with studying chemistry among students in the experimental (*HRA*) group before and after the intervention program, and the t value of the difference

Group	N	Mean (1-100)	Standard deviation	*t*
Before	61	80.38	10.33	
After	61	91.28	7.13	6.78***
*** p<0.001				

The findings, presented in Table 8, show a significant difference between the level of academic achievement in studying chemistry among students in the experimental group (*HRA*) before and after the intervention program. The mean of the students' academic achievements after the intervention is higher than the mean before the intervention. In other words, the academic achievements in science among students who participated in the intervention program improved.

In the third stage, the difference in the academic achievements of the experimental group (*HRA*) after implementing the intervention program was compared to those of the control group (*LRA*). The difference between the two groups was determined by means of a *t*-test for two independent samples.

Table 9. Means and standard deviations for academic achievements when studying chemistry among students of both groups after the intervention program, and the *t* value of the difference

Group	N	Mean (1-100)	Standard deviation	t
Experimental (*HRA*)	61	91.28	7.13	
Control *(LRA)*	59	77.25	10.54	8.56***

*** $p<0.00$

The findings, presented in Table 9, show a significant difference in the academic achievements in chemistry among students in the two groups after the intervention. The mean motivation and satisfaction in the experimental group (*HRA*) after the intervention program is higher than the mean in the control group (*LRA*) after the intervention. In other words, the previously non-existing difference in academic achievement between the two groups became apparent. The intervention program in which science was taught to the experimental group (*HRA*) using the relevance method brought about an improvement in students' academic when studying chemistry.

In addition to the quantitative data produced by means of the questionnaires, a structured interview was conducted. Common answers that were repeatedly given to the different questions by the students that learned acid base concepts by using the *LRA* style of learning indicate that many students are not very interested in the content of school chemistry lessons. In fact, they wonder why they need to be familiar with chemistry concepts.

Implementation of an intervention program consisting of teaching students the topic of acids and bases using the *HRA* improved students' attitudes towards chemistry and its study. Next, common answers that were repeatedly given to the different questions are displayed:

Student 1: *"Science helps in getting a better understanding of life and events. It had a positive effect on my understanding of chemistry."*

Student 2: *"Giving examples from everyday occurrences, in order to help students gain a better understanding; connecting the subject with life."*

Student 3: *"It makes me want to implement things in daily life; it exposes me to a variety of different topics, how they are used, their dangers, and their effects."*

Student 4: *"I will continue to study science. It had a very positive influence and raised my motivation and my satisfaction; perhaps I might even become a chemistry teacher or scientist in the future."*

The students' responses led us to conclude that learning chemistry using the *HRA* had a very positive effect: It made them appreciate the subject, made it seem less difficult, and made it more interesting and attractive. Stucky et al. [13] reported the contribution to the three dimensions: *individual* (student 1 and student 2), *social* (student 3 and student 3), and *vocational* (student 4). These dimensions raised the level of motivation and satisfaction among the students, mainly because of the latter's more positive attitudes towards chemistry due to the connection made between chemistry and students' daily lives.

7. Discussion

Some students who study chemistry do so because they wish to devote their future to the mathematical analysis of chemical processes. Others are enticed in studying the human body, among other reasons. Indeed, interest in the subject matter plays a crucial role in enhancing motivation and success among learners. It is important therefore, to emphasize that teaching the topic of acids and bases by means of *HRA* can attain this goal.

In this study, the researchers examined how studying chemistry (specifically, acids and bases) by means of the *HRA* correlates with improved student academic achievements in chemistry, attitudes towards science, motivation, and satisfaction. Relevance is an increasingly important factor because, based on the declaration made by the Ministry of Education in Israel, quite a few reforms and changes are being carried out in Israel in order to promote teaching that places the student in the center.

The value of the present study lies in its highlighting the need to create relevance when teaching science to students; its findings show that emphasizing the learned subject's relevance can generate a process of improving a learners' achievements in knowledge-type tests.

The study also demonstrates that an intervention program in which students in the experimental group (*HRA*) are taught the topic of acids and bases by means of the relevance method improved students' attitudes towards the sciences and studying chemistry and supports the three dimensions: *individual, social, and vocational*. This post-intervention improvement in the results of the experimental (*HRA*) compared to the control group (*LRA*) is statistically significant (Tables 6 and 9). These findings are in agreement with those of other studies [28-30] in which students' attitudes towards science and mathematics were tested, with an emphasis on students' attitudes towards and love of science, the significance that they ascribe to the subject, and their degree of self-confidence as learners.

Students in the experimental group (*HRA*), in which the subject of acids and bases was instructed by means of the relevance method, experienced a rise in their level of motivation and satisfaction with respect to the study of science, in comparison with students who were instructed by means of *LRA*. The difference between the two groups was significant. This finding is in accordance with other studies [31] in which the highest quality of conceptual learning occurred under conditions of motivation that promotes personal growth and a reshaping of one's worldview.

Above all, this study demonstrates a significant improvement in academic achievement in the field of chemistry among students who were instructed by means of the *HRA* in comparison with students who were instructed by means of the *LRA* (Table 7).

The findings also highlight the importance of the *HRA* in teaching acid-base concepts, in line with studies on meaningful, relevant experiential learning, which emphasizes that the creation of meaning must begin immediately after the student enters school, by associating the subject matter with the child's experiences and home culture. Bruner affirms that culture affects learning by providing children with a toolbox with which they can build up their world and their personal conceptions and understanding. [32] Therefore, teachers must become acquainted with children's actual world and the influences that shape them. [33]

In an example from the *LRA* in teaching acid-base concepts, the instructor announced that today's lesson would be about "titration of acid "HCl" and base "NaOH" using Phenolphthalein as an indicator for acids and bases". The students were then asked: "*What is the connection between phenolphthalein and the indicator for acids and bases and daily life.*" This question initiated a context-based learning process. One of the student's reactions was: "*I have no idea about the relation between HCl, NaOH and in the future if I will become a teacher I will not teach this topic, because my student will not connect this topic to daily life ".* Another student's reaction was: "*I don't want to become chemistry teacher in the future; the subject has no connection to our daily life*". These students' reactions clearly indicate that using *LRA* in teaching the acid-base topic does not supports the *vocational dimension*. From other students' reactions its clearly that using the *LRA* in teaching the acid-base topic does not supports the *social, individual and vocational dimension*.

In an example from the *HRA* in teaching acid-base concepts, the instructor announced that today's lesson would be about "red cabbage juice", as one example of an indicator for acids and bases. The students were then asked: "*What is the connection between red cabbage juice and the indicator for acids and bases.*" This question initiated a context-based learning process. One of the student's reactions was: "*Only now do I understand how I will become a different teacher in the future".* Another student's reaction was: "*Now, I want to be researcher in the field of food chemistry*". These students' reactions clearly indicate that using *HRA* in teaching the acid-base topic supports the *vocational dimension*.

In another example from the *HRA* in teaching the acid-base topic, the instructor announced that today's lesson would be about "acid rain", as one example of producing acids. The students were then asked: "*What is the connection between acid rain and the production of acids?*" This question initiated a context-based learning process. One of the student's reactions was: "*Now I will be more active in the future in the field of environmental protection save our planet".* Another student's reaction was: "*I want to be a researcher and develop methods that will reduce the amount of gases responsible for acid rain* ". These students' reactions clearly indicate that using the *HRA* in teaching the acid-base topic supports the *social dimension and the vocational dimension*.

In another example from the *HRA* in teaching the acid-base topic, the instructor announced that today's lesson would be about "is every transparent liquid water?" as one example of acid-base. The students were then asked: "*What is the connection between this topic and the acid base one.*" This question initiated a context-based learning process. One of the student's reactions was: "*This topic increased my interest and curiosity to think about the subject of acids and bases".* Another student's reactions was: "*This topic made me think deeply of transparent and acidic fluids encountered in everyday life*". These students' reactions clearly indicate that using the *HRA* in teaching the acid-base topic supports the *individual dimension*.

The Ministry of Education designs the curriculum. The officials responsible for its implementation try to link its objectives to the students' world. However, not every student comes to class with a burning desire to “reach the summit”, so part of the teacher's job is to make the information and skills accessible to the students from their standpoint. However, it is no easy task to make topics in chemistry or biology understandable to most students; this requires considerable thought and careful planning, and requires lesson plans that are flexible enough so that they can be adapted to the learning population and to developments in the classroom. For this reason, the researchers of this study wish to stress the need for relevance and interest in order to improve learning and enhance the learners' sense of belonging to the science curriculum and to the scientific community. Therefore, it is essential to continue to build bridges between the curriculum and the students' world in order to narrow the gap in learning.

8. Conclusions

The present study's main conclusion is that teaching a topic using a relevancy-oriented method enhances the levels of student motivation and satisfaction and improves students' attitudes towards science and its learning. For this reason, the authors highly recommend the use of the relevance method for teaching science as well as to include laboratory experiments in order to make the learning process more experiential and significant. This research focuses on the relevance of chemistry education. It was inspired by a recently suggested definition and model of the relevance of science education in its adjustment to the teaching and learning of chemistry. [13-15, 21, 22]

This study is also in agreement with the recommendation made by Fensham, [27] who urges adopting science education methods based on socio-scientific issues, despite the method's social emphasis. Fensham contends that this type of science education helps students learn and understand the interconnections between science and society and helps them develop skills that will encourage them in the future to participate in scientific discussions and decision-making processes in society. In addition, with this type of science education students are also required to learn intellectually challenging scientific skills. For this reason, the proposed method of this research is imperative, since it also presents students with various possible paths for career development.

The amount of instruction may be varied to suit different age groups. For this reason, Fensham developed a general structure for a twelve-year science curriculum, [33] with different emphases for different age groups. During the first five years, the emphasis is on "wonder and creativity". Subsequently the context moves towards science, civics, and emphasis on self-awareness and decision-making. The professional dimension is combined with the changing emphases. [33] However, since this study focuses on one specific topic (acid-base), it is advisable to test the effects of the intervention program on other, more complex topics over a longer period.

In light of these findings, it can be concluded that teaching chemistry using the *HRA* method increased student motivation and satisfaction and improved their attitudes towards chemistry and its study, and supported the three dimension: *individual, social, and vocational*. On the other hand, the intervention program in which chemistry was taught to the experimental group (*HRA*) using the relevance method improved students' achievements when studying chemistry.

9. Associated Content

Supporting Information

This part contain the lessons, activities and experiment, which will be implemented during the *Low Relevance Approach (LRA) and the High relevance Approach.*

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