

Bilingual education as a means of improving future natural sciences teachers quality of education

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Abstract. The article deals with the problem of introduction of the elements of bilingual education in professional training of future natural sciences teachers. It has been found out that Ukraine has some historical experience of introducing bilingual education in general secondary education institutions. It has been revealed that the main drawback, in this perspective, is the training of future teachers who would be able to provide the opportunity for school students to study natural sciences subjects in two languages. The content of the elective course “Science teachers training in US universities” which is taught in English, as one of the means of ensuring a “parity model” of bilingual education for future natural sciences teachers and a “displacing model” has been revealed. Learning of this course involves a dual purpose – the formation of students’ knowledge of the concept of natural sciences teachers training in the United States (structure, features of the content, forms and methods of natural sciences teachers training under conditions of continuous pedagogical education) and adaptation of this knowledge to the educational process in Ukraine; formation of intercultural interaction skills. The peculiarity of the training technology is that teaching is carried out in English depending on the level of students’ foreign language competence formation and educational tasks complexity. It has been established that the teaching methods which include the use of different doses of assistance during the performance of cognitive tasks and differentiating of their complexity level are effective while teaching this course. The use of such teaching methods allows to provide each student with the optimal conditions for the maximum satisfaction of his cognitive needs and formation of communicative skills. These methods involve a gradual transition from collective forms of work to partially independent and fully independent and performing of the tasks, the complexity of which is growing. The effectiveness of the content of the course “Science teachers training in US universities” according to such a criterion as didactic quality has been experimentally proved. The quality of its study by the criterion of formation of methods of mental activity and development of types of speech activity has been confirmed.

Keywords: bilingual education, future teachers, natural sciences, elective course, content, dose of assistance

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1. Introduction

Current social and economic as well as political changes in the world require more active participation of different countries in the world geopolitical multicultural dialogue. One of the factors of such a dialogue intensification is the necessity to master at least one foreign language fluently. This has led to the emergence of such a phenomenon as bilingual education in the world educational practice. Creation and strengthening of the interrelations of pedagogical and scientific communities from different countries of the world naturally actualize the need for research of bilingual training. Its introducing will ensure active communication of the subjects of the educational process, expand employment opportunities and provide preferences in career growth. It's a gratifying fact that the national policy of industry specialists training who would be recognized by other countries and be competitive in today's labour market has undergone significant positive changes, especially with regard to the level of learning foreign languages, in general and foreign languages in professional sphere, in particular.

The development of bilingual education in Ukraine, which is caused by the current general trend towards integration into the European space and the desire for intercultural dialogue and intercultural communication, has certain historical roots. Thus, in the 60's and 70's of the XX century bilingual learning technologies were actively introduced in general secondary schools with advanced foreign language learning. Based on our own experience we know that at that time, for example, in Ternopil school № 3 specialized in learning foreign languages, the school subject "Geography" (6th grade) was studied in a foreign language (English). Such subjects as "English Literature", "American Literature", "Technical Translation", "United States Navy" were added to the school subject "English" in high school. On Tuesdays they used to conduct political information (reports on recent home and international events) in English. Herewith, they were conducted for all high school students. Once a week there was an English day, when the broadcasting of all programs on school radio was carried out in English. This experience remained and is actively used nowadays. But both then and now, there is a problem of training teachers, who would obtain, for example, natural sciences education and could teach schoolchildren in English. All this actualizes the problem of introduction of bilingual education in professional training of future natural sciences teachers.

The state and prospects of future natural sciences teachers training was the subject of our study [19]. Regarding bilingual education, the analysis of literature sources showed that the theoretical foundations of bilingualism in Ukraine are reflected in the works of Baditsa, Kolesnyk and Polkhovska [3], Bodnarchuk [5], Goroshkina [6], Ihnatenko [7], Konoval et al. [9], Kotlovskiy et al. [10], Shirin [18], Sulik [20], Sytnyakivska and Khlyvnyuk [22], Ustymenko and Hamaniuk [23]. Their researches prove that bilingual education is a purposeful process of involvement in the world culture through native and foreign languages, when a foreign language acts as a means of cognizing the world, acquiring special knowledge, learning cultural, historical and social experience of different countries and peoples. Their researches prove that bilingual education is a purposeful process of involvement in the world culture through native and foreign languages, when a foreign language acts as a means of cognizing the world, acquiring special knowledge, learning cultural, historical and social experience of different countries and peoples. Along with this the forms of using two languages, as well as the types of didactic materials and their language are not regulated, but their level should correspond to the

average language competence of the reference group.

Comparison of the students' attitude to bilingual education in Ukraine and Poland was conducted by Sytniakivska and Sejko [21]. Generalization of the ideas of American experience regarding bilingual education as a means of ensuring effective intercultural interaction in a multinational state was conducted by Bartosh [4].

The problem of introduction the elements of bilingual education in professional training of future natural sciences teachers has been partly explained in our work [16]. The advantage of such education is that it is a step towards multicultural education. Disadvantages are connected with the imperfection of the system of bilingual teachers training and the lack of appropriate textbooks. It has been established that bilingual education is a variety of models and programs united by a single principle: two languages are used as a means of teaching. The following models of bilingual education are known: dubbing or accompanying (used, as a rule, at the initial stage of training and offers representation of the same unit in native and foreign languages); supplementary (provides the submission of additional information in the foreign language, which partially or significantly enriches the content learned in the native language); parity (provides equal use of native and foreign languages in the disclosure of the content of the course); displacing model (foreign language dominates in the disclosure of the course content). However, today all these models require further research in the context of their content.

The **goal** of the article is to develop the content of the elective course "Science teachers training in US universities", which is taught in English as a means of bilingual education of future natural sciences teachers and substantiate its effectiveness experimentally.

2. Research methods

To achieve the above-mentioned goal, a number of methods have been used, namely:

- *theoretical* – comparative analysis to find out different views on the problem, identify areas of study;
- *modeling* – to develop a model of the elective course "Science teachers training in US universities";
- *constructing* – for the development of the course component, the criterion apparatus of the research, systematization and generalization to formulate conclusions and recommendations for improving the educational process with a view to raise the quality of educational services at higher education institutions;
- *empirical* – generalization of pedagogical experience, scientific observation, interviews, content analysis, questionnaires in order to determine the state of implementation of the problem in practice and to develop the content of experimental teaching methodology; pedagogical experiment, which provided verification of the effectiveness of the proposed methodology, methods of expert evaluation to determine the didactic quality of the developed experimental materials.

Experimental research has been carried out on the basis of Ternopil Volodymyr Hnatiuk National Pedagogical University. Effectiveness of the proposed methodology was checked

during the forming experiment. Experimental research lasted for two years (2019-2020 and 2020-2021 academic years) in the process of future natural sciences teachers professional training. It involved 21 lecturers of higher education institutions and 105 students of the second (master's) level of higher education of the educational and professional program Secondary education (Natural sciences). Out of them 80 people participated in the summative stage of experimental research and 25 people were involved in forming experiment.

The methodology of experimental research was implemented according to the following stages: preparatory; organizational and methodological; procedural; reflexive-analytical. At the first stage there was a study using methods of questionnaires, conversations to find out the needs of the subjects of educational interaction concerning the improvement the quality of educational services at the higher education institution. To meet the identified needs, we focused on studying the problem of bilingual education, developing the content of the elective course "Science teachers training in US universities", the teaching of which was carried out in English. The criterion apparatus of the research (criteria and indicators of the proposed course efficiency) was also determined.

At the organizational and methodological stage, the priorities of students in educational and organizational activities to study the proposed course among a number of elective courses were determined. The procedural stage involved the study of the proposed course. At the reflexive-analytical stage of the research, the results of experimental training were analyzed according to objective and subjective indicators.

3. Results and discussion

In developing the issue of introducing the elements of bilingual education in the training of future natural sciences teachers, we followed the assumption that such training is more effective than classical. It facilitates the development of students' general competencies, which in the future will enable them to compete not only in the Ukrainian but also in the world labour market. Along with this the following axiom was taken into consideration, that the solution of the problem of continuous improvement of professional training of future teachers in higher pedagogical educational institutions will be effective if it takes place not only taking into account the best examples of Ukrainian pedagogical education, but also with introduction of positive experience of professional training of teachers abroad, in particular in the US. It is in this country where multicultural education has the status of public policy, which has been legally regulated (the Bilingual Education Act), a special unit of measurement of the degree of competence aging (half-life of knowledge), which actualizes the need to interpret education as a continuous learning process has been established. More over, the US demonstrates a high level of development of natural science education, and hence the professional competence of teachers.

With the aim of introducing bilingual education in professional training of teachers, we have developed a program of the course "Science teachers training in US universities", which is the result of our scientific research [15]. This course belongs to the block of elective disciplines of methodological direction. It has been included in the curriculum for training students of the second (master's) level of higher education in the specialty 014.15 Secondary education

(Natural Sciences) and 014.05 Secondary education (Biology and Human Health) of the Faculty of Chemistry and Biology of Ternopil Volodymyr Hnatiuk National Pedagogical University. The course studying involves a dual purpose – the formation of students' knowledge of the concept of training natural sciences teachers in the United States (structure, features of content, forms and methods of teaching natural sciences teachers in the process of continuing pedagogical education); formation of the skills of intercultural interaction. The specificity of the course is teaching in English, depending on the level of students' foreign language competence formation.

Since students are enrolled for the second (master's) level of higher education with different levels of knowledge and skills in the foreign language, thus to form a foreign language competence, the teacher has to use different methods and approaches in the process of foreign language teaching. Taking into consideration the results of research of Amelina et al. [1], Kotlovskiy et al. [10], Kuts and Lavrentieva [11], Malykhin and Bondarevska [12], Morska [13], Nikolaeva, Zadorozhna and Datskiv [14], Volkova et al. [24], Zadorozhna, Datskiv and Shon [25], Zadorozhna, Klymenko and Quam [26] and the experience of conducting classes we came to the conclusion that teaching methods which include the use of different doses of assistance (according to Babansky [2]) during the performance of cognitive tasks are effective. Their use allows to provide each student with conditions for the maximum satisfaction of his cognitive needs and interests in the process of mastering educational material, formation of communicative skills. When planning tasks, the lecturer takes into account the level of students' knowledge in a foreign language, and this makes it possible to create tasks of different levels of complexity and, accordingly, groups to discuss topics. In case of providing students with doses of assistance, the lecturer offers tasks himself, but the amount of the dose depends on the student. In the process of such training there is a gradual transition from collective forms of work to partially independent and fully independent. Such an approach involves the tasks the complexity of which increases.

Thus, in the process of course teaching there is a generalization of all knowledge and skills acquired by the student during the study of natural sciences at the university (in particular, during pedagogical and scientific-pedagogical practices) and, based on the acquired knowledge, comparison of the process of professional-methodological competence formation of the future natural sciences teacher in Ukraine and the US. Teaching of the course in English guarantees a significant improvement of foreign language competence. The scope of the course is 3 ECTS credits, the total number of hours is 90. Out of which, 10 hours are assigned for lectures, 20 hours for practical classes, and the remaining 60 hours for independent and individual work of undergraduates [15].

Lectures involve the study of general issues related to the organization and content of future natural sciences teachers training in the United States, forms and methods of professional training and monitoring the quality of natural sciences education in US universities. Thus, the students are offered to study the following topics: "Formation of the future natural sciences teacher's professionalism and his professional and methodological competence", "Normative sources of constructing the content of natural sciences teachers training in the US", "Content, forms and methods of natural sciences teachers professional training for the beginning of pedagogical activities", "Organization of natural sciences teachers professional training during pedagogical activities", "Methods of teachers professional training in the US", "Peculiarities of organization of future natural sciences teachers professional training in the US and Ukraine",

“Concept of monitoring. The essence and criteria of monitoring of education in US universities”, “Structure and standards of natural sciences education in US universities”, “Monitoring studies of students’ outcomes quality in US universities”, “Process and result as components of monitoring the quality of natural sciences education”, etc.

Practical classes are aimed at deepening the content of the main topics of the lectures through the study of components that ensure the high professionalism of natural sciences teachers in the United States; the main normative sources that determine the essence of professional training and pedagogical activities of natural sciences teachers in the United States; features of curricula for natural sciences teachers training in the United States; methods of natural sciences teachers professional training in the US, etc.

The content of the course is divided into two thematic modules: “Training of a natural sciences teacher in the US” and “Monitoring the quality of natural sciences education in the US”. Due to the fact that the content of the course is clearly structured, its scope can be easily expanded, and the topics can vary. Students’ independent work involves the work with literary scientific sources on the problems that are partially explained during lectures or discussed at practical classes.

Educational materials which are intended for students’ self-study are suitable for independent study according to the level of difficulty; expand, supplement, specify the knowledge of the fundamentals studied at the basic course; practical materials, that is, those that illustrate the application of general principles, namely: components of natural sciences teachers professional training in the United States; main stages of pedagogical practice at school; types of professional training methods that are implemented during the study of natural sciences and their characteristics; main differences between the Ukrainian and American systems of pedagogical education; comparative analysis of the content of American and Ukrainian training programs for future natural sciences teachers; characteristics of the requirements for the professions of the field of knowledge “Natural Sciences”, etc. The total number of hours assigned for students’ independent work is 52 hours.

The purpose of the student’s independent work is the formation of independence in the acquisition and deepening of knowledge, which will increase the competitiveness of future specialists in the labour market. Practical experience and observations show that independent work becomes effective in teaching English for professional purposes in 5th and 6th years of study, as it provides an opportunity to optimize the educational process when the masters are busy with different projects, disciplines on specialty, preparation of master’s thesis. With the aim of improving the organization of students’ independent work at higher education institutions, information technologies and e-learning environment are successfully used. It must be noted, that under such conditions, learning outcomes improve, undergraduates gain additional skills in working with information, which also increase motivation. A very important result of such training is the formation of skills to plan and organize their learning strategy, the development of skills of autonomous learning. At the same time the role of the lecturer changes, he turns from a traditional mentor into an organizer and moderator of the educational process. The lecturer acts as a partner and assistant, supporting, guiding and controlling the cognitive activity of future specialists. One of the main tasks for the lecturer is the correct organization of the educational process.

Students’ research work is aimed at the mastering of the skills of independent information

processing (primarily – information from electronic sources). In particular, students independently analyze and compare elements of Ukrainian, American and European experience in the training of natural sciences teachers, as well as compile a glossary to the topics and translate abstracted texts. In addition, the students study the process of natural sciences teacher's certification. An interesting example of research work is scholarly studies related to examples of developing a lesson plan and preparing for its conducting. To provide the integration of educational and scientific-research activities of the students, a web page "Scientific progress" has been created on the official website of Ternopil Volodymyr Hnatiuk National Pedagogical University, which contains a collection of scientific papers "The Scientific Issues of Ternopil Volodymyr Hnatiuk National Pedagogical University" Series "Biology" and materials of annual international scientific-practical conferences "Physics, Chemistry, Biology and Natural Sciences teachers training in the context of the requirements of the New Ukrainian School" and "Ternopil Bioscience", give undergraduates the possibility to demonstrate the results of their research.

Organizational and methodological support of educational process is based on the developing of educational and methodological complex of a course, which includes: program of the course; syllabus; textbooks and manuals; methodological materials and tasks for lectures and practical classes; individual tasks for independent work of students; current and final tests to check the level of acquisition of educational material by the students.

On purpose to determine the criteria for the effectiveness of the study of the course, we analyzed the essence of the general competencies that future teachers should have according to the Professional Standard for Teachers [17], and a survey of students. The results which we have received allow us to state that the study of the course "Science teachers training in US universities" has the greatest impact on the formation of such general competencies as: mastery of communication skills (this is the opinion of 92% of the respondents); ability to search, process and analyze information from various sources (96%); ability to apply best practices in professional activities (84%). Therefore, two criteria have been chosen: the level of formation of mental activity techniques (IQ); development of speech activities.

The first criterion is interpreted by us as an integrated indicator of the formation of the ability to analyze, compare and draw conclusions from known theoretical information and practical activities. It was identified through the analysis of students' opinions on the diversity and effectiveness of teaching methods used by lecturers of Ukrainian higher education institutions. The students made their conclusions on the basis of a comparison of theoretical knowledge gained during the course and personal experience, the real practice of future natural sciences teachers training.

The second criterion was determined on the basis of reflection the level of students' own achievements in mastering four main types of speech activity: reading and reading comprehension (adapted and non-adapted popular and scientific sources, lecture materials, manuals, textbooks and scientific articles, tests, media, English texts from Web-based resources, including software for the use of English-language sites, annotation and abstracting of texts); listening and listening comprehension (teacher's speech during the lectures, understanding of interpersonal communication during practical classes, understanding of audio-Internet conferences, round tables, seminars, authentic audio recordings of scientific films, feature films of socio-pedagogical orientation); speaking (monologue and dialogue speech at classes, communication during practice, delivering speeches at conferences with the participation of foreign scientists); writing

(writing notes at lectures, performing of social and pedagogical tasks, writing abstracts to scientific articles, writing a resume for further employment, preparation of scientific reports for participation in grants, writing of theses and reports to participate in international students conferences).

To assess the quality of the proposed course, an integrated criterion of “didactic quality” was used, which was determined by the method of expert evaluation [8]. A group of experts was formed to conduct the research, which included scientists and lecturers of pedagogical higher education institutions from different regions of Ukraine, who agreed to participate in the examination. We deliberately chose a non-homogeneous expert group in terms of composition in order to take into account more fully possible opinions on the compliance of the proposed content with the needs and real conditions of teaching practice and the current state of development of pedagogical science. The quality of experts was high, as all of them were sufficiently characterized by such important features as: competence; interest in the results of the examination; businesslike character; objectivity and impartiality.

The expert group included:

1. Lecturers and scientists of Ternopil Volodymyr Hnatiuk National Pedagogical University, National Pedagogical Dragomanov University and Sumy State Pedagogical University named after A.S. Makarenko.
2. Students of the second (master’s) level of higher education.

The information about experts is as follows: out of 21 respondents there were 6 Doctors in Pedagogical Sciences, 5 PhD and Associate Professors and 10 students.

A group of specialists especially competent in the field of the studied problem (5 people) was selected out of the total number of experts. It comprised foreign languages lecturers and methods of teaching natural sciences lecturers who have a degree and teaching experience of more than 10 years.

Indicators, according to which the content of courses of studies was later assessed, were agreed with this group of experts. As a result of collective discussion, following the condition that examples of in-text equations in context. Notice how this equation: $\sum_{i=1}^6 K_i$, the “weight” (K) of each of the six selected indicators was determined. The results are presented in table 1.

The examination was conducted in May 2019. 4 contents of the course “Science teachers training in US universities” were undergone the examination: I – lectures; II – practical classes; III – tasks for independent work; IV – control and reflexive tasks. Their content was evaluated according to the integrated indicator “didactic quality”. It was defined as the degree of correspondence of each submitted to the examination content to the totality of the mentioned indicators.

Invited experts were informed the objective of the experiment and the rules of its conducting. They were given the information concerning general approaches to solving the problem. After that each expert filled in individually the questionnaire, which included a set of factors that were assessed. The questionnaires were studied and analyzed.

The results of the expert assessment convincingly showed the possibility and expediency of including the course “Science teachers training in US universities” in the curriculum for

Table 1

The weight of indicators of the content of courses didactic quality.

№	Indicators	Weight
1.	Significance for soft skills formation, which are listed in educational and professional program	25
2.	Significance for hard skills formation, which are listed in educational and professional program	25
3.	Significance for the organization of interactive pedagogical cooperation of the educational process participants	10
4.	Accessibility for perception	10
5.	Expediency of use during future teachers professional training	20
6.	Correspondence to the life experience of scientists, lecturers and students	10

the training students of second (master's) level of higher education of the educational and professional program Secondary education (Natural sciences). According to the experts, its content is available on the whole, for perception and is important for improving the quality of future teachers professional training.

To assess the quality of the proposed course, the students were asked to answer the questions of the questionnaires after studying it. To answer the first question ("Indicate the forms, methods, techniques and technologies that were used by the teachers at lectures to ensure the educational process"), the students were offered a list of methods and techniques of conducting lectures (monologue presentation of the material, binary lecture, special guest invitation, lecture-discussion, "feedback cards", voting, discussion in subgroups, working in pairs, press conference, aquarium, problem solving, debates, Abercrombie groups, outdoor conversation, lecture-excursion, creating an intelligent map during the lecture, role-playing games, brainstorming, debate, free discussion, self-assessment groups, syndicates, training groups, flipped lectures, lecture with pre-planned mistakes). Each method or technique had to be assigned to one of the three categories: "often", "rarely", "never". The analysis of students' answers showed that among the methods that are often used during the future natural sciences teachers training are the following: lecture-discussion (64% of respondents); discussion in subgroups (68%), working in pairs during the lecture (60%), free discussion (32%). Also, 80% of respondents state that frequently lectures are held in the form of a lecturer's monologue, which is not typical of US universities.

The methods which were rarely used at the lectures are as follows: voting (84%), press conference (64%), brainstorming (20%), special guest invitation (92%); training groups (40%); debates (48%), problem solving (56%), lectures in the form of excursions (60%), work in self-assessment groups (80%). Among the methods which are used in US higher education institutions, but never encountered by the respondents were mentioned the following: binary lecture (96%); "feedback cards" (80%); aquarium (88%); Abercrombie groups (82%); outdoor classes (56%); use of role-playing games (64%); syndicates (60%); flipped lectures (96%); lectures with pre-planned mistakes (76%); debate (40%).

Answering the question "What techniques, methods, technologies are used during seminars?", respondents note that the following ones are often used: presentations and discussions (92%),

working in pairs (64%), project doing (56%), brainstorming (40%).

Among the methods that are rarely used during the seminars are the following: self-assessment groups (40%), “flow of ideas” (64%), round table (52%); essay writing (64%); situations modeling (56%); training groups (60%); “microteaching” (52%); case study (36%).

Teaching was never organized at the seminars using the following technologies: Abercrombie groups (80%); video recordings of students’ micro-teaching and their further discussion (88%); press conference (52%); role-playing games (72%); interdisciplinary seminars (56%); special seminars (52%); syndicates (64%); “decision tree” (72%).

According to the respondents, rather often during laboratory and practical classes, teaching was organized using the following methods: work with various equipment (96%); experimentations (100%); frontal survey (96%); individual survey (100%); testing (88%); performing the experiment (64%); conducting research (68%); problem solving (76%); observation of objects (72%); doing exercises (84%); demonstrations (68% of respondents).

Methods that were widely used at laboratory and practical classes during natural sciences teachers training in the United States, but rarely among Ukrainian students are as follows: doing projects (64%); heuristic conversation (48%); making visual teaching aids (40%). The respondents state that none of the enumerated methods can be classified as “never used”. Analyzing answers to the question “What methods of independent work do you use during studying?” it was found out that often independent work is organized using the following methods and techniques: preparation of a report (64%); work with various literature (68%); problem solving, calculations, exercises, individual tasks (76%); control or test questions answering (84%); performance of an individual research task (64%); independent doing the project (40%). Such technologies are rarely used in the organization of students’ independent work: abstracts writing (52%); essay writing (64%); work with scientific articles (52%).

The conducted qualitative analysis of students’ answers testified a sufficient level of their mental activity techniques formation, which they effectively use in non-standard conditions of changing educational environment and make adequate conclusions.

The quality of providing educational services according to the second criterion was determined by analyzing the results of students’ reflection on increasing the level of their mastery of four types of speech activity as a result of mastering the content of the course (table 2).

Table 2

Results of students’ reflection on increasing the level of their speech activity.

№	Type of speech activity	Increased considerably	Increased partially	No changes
1.	Reading and reading comprehension	28%	60%	12%
2.	Listening and listening comprehension	32%	60%	8%
3.	Speaking	80%	16%	4%
4.	Writing	4%	20%	72%

4. Conclusions

The process of bilingual education spread is inevitable for Ukraine, although this process is accompanied by a large number of problems related to the organization of such education, as well as to the determination of its goals and evaluation of results. The conducted research is connected with the creation of a training base for teachers of the new generation with high rates of intellectual development and emotional intelligence, providing conditions for the formation and development of modern models of personal development of teachers.

Inclusion of the elective course “Science teachers training in US universities” in the curriculum for future natural sciences teachers training helps to attract students to the world culture through the foreign language, which serves as a means of learning the world, acquisition of special knowledge, learning cultural, historical and social experience of different countries and peoples; broadens the possibilities of future specialists adaptation in various social, informational and scientific realities of nowadays; improves the quality of intercultural communication, the importance of which is growing in a globalized world. The prospects for further study consist in the development of the content of other courses for professional training of future natural sciences teachers.

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