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Students' independent work in genetics in a multilingual education setting

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ABSTRACT
The study examines the role of independent work in enhancing the genetic knowledge of third-year biology students within a multilingual education setting. Conducted at Abai Kazakh National Pedagogical University, the research involved 164 biology teacher candidates. A quasi-experimental design with pre-test and post-test measures was employed to compare the effectiveness of various independent work methods in control and experimental groups. The findings reveal that independent work significantly improves students' understanding of genetics, particularly when supplemented with technology and project-based learning. However, students faced challenges due to limited resources in their native languages. The study concludes that independent work, guided by appropriate pedagogical strategies, is essential for developing genetic knowledge in a multilingual context. The implications for educators include the need for tailored resources and enhanced lecturer guidance in independent work.

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Introduction

Independent student work is essential to the learning process, as it forms professional competence on a subject matter and maintains motivation for further self-development. During independent work, students acquire cognitive techniques, develop their interest in creative work, improve logical and critical thinking skills, and gain the ability to solve scientific problems (Abilkhamitkyzy et al., 2014; Azamjonovich et al., 2023; Musakhonovna & Uchkurova, 2023). In this study, we adopt Abilkhamitkyzy's (2014) definition of student independent work as forming the

necessary level of knowledge, skills, and abilities to solve cognitive tasks in isolation and showing progression from ignorance to knowledge. Investigations of undergraduate students undertaking biology in general, and specifically genetics, reveal that these students tend to have difficulties forming independent-study behaviours (Abilkhamitkyzy et al., 2014; Buma and Nyamupangedengu, 2020; Peacock & Cowan, 2018). These challenges could be attributed to the complicated language of genetics, differences in the presentation of genetic materials, and complex genetics laws. Intensive and abstract vocabulary is a factor that causes students at all levels to struggle with learning biology (Kıryak et al., 2024). For example, terms such as mitosis, meiosis, genetic engineering, genes and chromosomes, require a teacher to expound upon (Tekkaya et al., 2001). Buma and Nyamupangedengu (2020), Singer, and Smith's (2013) studies revealed that undergraduate students reported minimal independent work findings as they focused on teacher-based study approaches. However, Tazhbayeva et al. (2014) highlighted that there were academic reforms in Kazakhstan advocating individualism and pragmatism (Tazhbayeva et al., 2014) and the prevalence of online learning during the current unprecedented times (e.g., coronavirus, Mertens et al., 2020) and have prompted students to pursue independent work in sciences (e.g., biology). The students' need to adapt to the reformed socioeconomic environment requires the promotion of independent work among Kazakhstan undergraduate students. Lecturers are expected to initiate, sustain and stimulate meaningful discourse for active participation so that the students achieve meaningful learning outcomes (Anderson et al., 2001; Garrison and Akyol, 2013;).They should lead students in accordance with their abilities and competencies and inspire self-confidence in them. Students in an independent work are not only expected to fulfill the tasks assigned to them but should also be able to identify and work on the necessary tasks depending on own needs, interests and abilities (Kurbanova, 2023). Previous research has shown that students show significant improvement in their collaboration and independent work schedules (Çepni & Şahin, 2010; Peacock & Cowan, 2018) when it is lecturer-led. In this current study, we posit that lecturers play a critical role in creating and sustaining an independent student study.

Genetics course lecturers must prepare students for independent work (Peacock & Cowan, 2018). This requires lecturers to reallocate responsibilities (e.g., laboratory work, data collection, or analysis) from the lecturer to the student. Lecturers must create a programme structure that fulfills the expectations of independent student work. Furthermore, there must be an avenue for collaboration and community-based interactions (e.g., access to instructional resources and assessment schedules). All of these tasks should be undertaken before implementing independent work programmes; otherwise, the student behaviours might not produce desirable outcomes (Peacock & Cowan, 2018; Vlachopoulos and Cowan, 2010). Once the lecturers evaulate the tasks and provide feedback, so they can nurture the higher-level cognitive and interpersonal abilities that demand student engagement. Although the lecturers are involved, they do not interfere with or offer leads that outline how specific genetics-related tasks are executed (Peacock & Cowan, 2018; Vlachopoulos & Cowan, 2010).

Independent student study programmes follow the learning-centred approach, which is grounded in the community of inquiry framework. Its central tenets include a focus on how individuals collaborate to criticise discourse, construct personal meanings, and establish mutual understanding (Garrison, 2011). Garrison (2011, p. 21) states that the purpose of the community of inquiry framework is "the development of an appropriate, quality, generic educational experience in which learners engage in collaborative educational conversations and activities including discourse, and reflection". Garrison's (2011) community of inquiry framework is constructed by observing an independent student working in an online setting. Biology courses, such as genetics, are rarely studied online as they require face-to-face interactions and hands-on experiments (Buma & Nyamupangedengu, 2020). Therefore, implementing the community of inquiry framework (Garrison, 2011) poses a significant challenge. However, with the attention given to online communities (e.g., Peacock & Cowan, 2018), exploring how to balance an offline and online study environment for students undertaking genetics is worthwhile. There are studies proving the benefits of community inquiry (Cheung et al., 2020) and learning genetics with online contexts (Ristanto et al., 2022) in

learning science courses. Although community inquiry shows promising results for students undertaking science subjects, such as genetics, studies applying this pedagogy in the genetics classroom are lacking. This course involves students with an incredibly diverse prior knowledge and interest in science (Cheung et al., 2020) Therefore, this study's first contribution is that it builds on previous research (e.g., Peacock & Cowan, 2018) and adapts this framework to facilitating an independent student work.

Howe and Abedin's (2013) review consisted of one-hundred and fifty-eight studies. Although their findings were conclusive, they cannot be generalised for English-speaking students learning science, technology, engineering and mathematics (STEM) courses in languages other than English. Researchers (e.g., Boyle et al., 2020) have highlighted cross-cultural variations in learning styles. Although their findings have been significant, there have been few studies (Baikulova et al., 2017; Tazhbayeva et al., 2014) addressing the effects of cultural experiences in STEM education. According to Tazhbayeva and colleagues (2014), current Kazakh students have experienced market reforms and changing social relationships, which could be reflected in their value orientations. Therefore, students espouse individualism, pragmatism, and a desire to dominate their environment (Tazhbayeva et al., 2014). Since they desire to grow academically and professionally, these students pursue self-development opportunities (e.g. scientific and cultural information and computerization), which encourages independent work (Baikulova et al., 2017; Tazhbayeva et al., 2014).

Few recent studies have examined the role of independent study in science courses (Jones & Smith, 2022; Patel et al. 2021; Zhang & Liu, 2023). These studies examined independent work elements, such as training (Jones and Smith, 2022), time management (Patel et al. 2021), and self-assessment (Zhang & Liu, 2023), in isolation. The current study examines these three elements simultaneously in the context of biology students undertaking a genetics course. We argue that students must observe all independent work elements to achieve the desired learning outcomes. By examining the individual needs of students in genetics class, this study can help proving that science-based students can benefit from the skills proposed by Cowan (1978) and Watson and Gallagher (2005) such as planning, monitoring, and self-assessment.

Literature Review

A. Student Independent Work

Independent work is standard in practice but its conceptualisation varies across countries and disciplines (Abilkhamitkyzy et al., 2014; Hayes, 1999; Herppich et al., 2018; Ivanova and Logvinova, 2017). According to Herppich and colleagues (2018), independent work is an educational activity where students solve academic problems in isolation. Ivanova and Logvinova (2017) emphasise the process of independent knowledge acquisition through the independent study of educational material. Abilkhamitkyzy's (2014) definition focuses on forming the necessary volume of knowledge, skills and abilities to solve cognitive tasks at various complexity levels. The definition of Andreeva and colleagues (2020) stresses the benefits of independent study, i.e., it provides students an advantage over other students and extends the frontiers of their experience. Independent study fosters students in qualities such as their abilities, interests, tendencies, and needs (Richardson, 2005) that would be relevant in their professions (Balçıkanlı, 2010). In addition, independent study improves student autonomy (Cotterall, 2000), self-organisation and self-management (Abilkhamitkyzy et al., 2014), and research competence (Cao et al., 2017). Hayes (1999) determined that independent work was a source of vitality and considered it a life priority in some level. Various terms have been used to emphasise different aspects of independent studies such as indirect (isolated) learning (Balfakih, 2003), silent work (Serin, 2018), individual work (Hockings et al., 2018), and self-education (Fidyk, 2017).

Independent work gained prominence when Peters (1970) called for educators to offer their students learning autonomy. According to Peters (1970), individuals are intrinsically motivated to self-

understand, alter their self-concept, and eventually direct their own behaviour. This motivation can be utilised when individuals are placed in a favourable environment that better facilitates psychological attitudes (Peters, 1970), such as independent work. Boud (1988) reiterated Eters' (1970) observations and extensively examined the benefits of student autonomy in learning. Subsequently, researchers and practitioners (e.g., Anon, 1981; Candy, 2012; Dfes, 2004; Miliband, 2004) endorsed independent work principles. They argued that education should follow active learning methods when dealing with academic or industrial problems (Anon, 1981). This endorsement led to personalisation in education and promoted learner autonomy and life skills for lifelong learning (e.g., independent learning, decision-making, and planning (Anon, 1981; Candy, 2012; Dfes, 2004; Miliband, 2004)).
Students are considered partners in the learning process through independent work, while teachers are considered as peers (López-Pérez et al., 2011; Peacock & Cowan, 2018). Therefore, students are not only agents of change but also co-creators of the learning process (Debowski, 2007; Peacock & Cowan, 2018). Independent work is relevant in the current socioeconomic environment that is experiencing turbulences such as rapid technological change, diverse ideological convictions, (Peacock & Cowan, 2018). These shifts call for collaboration among all education stakeholders including parents, students and lecturers. Desired benefits of independent study significantly depend on relevant abilities such as analysing, evaluating, valuing, planning and managing (Debowski, 2007) in all areas of expertise such as biology and genetics.

Generally, students have diverse preferences, styles, approaches, abilities, and independent study skills (Candy, 2012; Ülger, 2021). As it is a self-directed initiative, students must collaborate with their lecturers to highlight suitable features and request support. A productive, independent work programme depends on the pace, the study method, and personalised tutorial support (Peacock & Cowan, 2018) of students. Recent research indicates that comprehensive independent study programmes can significantly enhance student outcomes in STEM fields. Johnson et al. (2023) demonstrated that structured training programmes improve students' ability to engage in self-directed learning. Similarly, Patel et al. (2022) found that effective time management strategies are crucial for independent worksuccess, while Wang and Liu (2023) highlighted the importance of self-assessment in fostering student autonomy and improving performance.
The effectiveness of independent work depends on the modern technologies offered by the teacher and various types of activities, such as projects, abstract presentation of material, and annotation (Gordeeva et al. 2024). In the works of Gulbahor and Umida (2022) depending on the goals, independent work can be divided into the following: - educational, education, correction, repetitive, developing, creative, control.

Synthesizing all these articles reviewed, it is clear that an integrated approach, combining training, time management, and self-assessment is essential for maximising the benefits of independent work. This study builds on these insights by examining these elements in unison, focusing on genetics students.

B. Cultural Influence on Independent Work

Culture arises from integrating human values, beliefs, and behaviour with the capacity of individuals to transmit this knowledge to subsequent generations (Fernandez et al., 2010). According to Klassen et al. (2013) traditions, language and the native tongue of the student and belief systems shape individual attitudes and motivation toward academic learning. Several studies have included culture as an explanatory variable (e.g., Bonneville-Roussy et al., 2019; Boyle et al., 2020). Culturally-shaped variables such as academic volitional strategies (e.g., Schlüter et al., 2018), moderate academic motivation and performance. Academic volitional strategies determine the degree to which students set, monitor, and manage their learning behaviours (Schlüter et al., 2018). In their study, Boyle and colleagues (2020) found that Thai university students were expected to listen carefully and respectfully without directly challenging the lecturer's authority. Thai students were required to uncritically memorise material, whereas Australian university students adopted a more critical

analytical style and closely evaluated the statements and assertions of lecturers (Boyle et al., 2020). Dennehy (2015) compared learning approaches between two heritages (Confucian vs. Western) and found that Asian students preferred surface learning (students reproduced facts through rote learning rather than understanding underlying principles). In contrast, Western students tended to adopt deep learning (where they mastered the learning material).

Recent studies have expanded on these concepts, emphasising the importance of individualised learning paths in higher education. For example, Roberts et al. (2022) found that personalised learning trajectories significantly enhance student engagement and performance in university-level STEM courses. Similarly, they demonstrated that incorporating flexible learning modules allows students to better integrate their interests with academic requirements, fostering deeper learning and self-motivation. Mwangi, Kitainge and Nyabuto (2023) studied the relationship between self-esteem and student maturity. The study found that there is a positive relationship between self-esteem motivation and the grade level of students. Cronin-Golomb and Bauer (2023) discussed the role of personal motivators such as self-efficacy beliefs and personality traits in self-motivated and directed lifelong learning. They then examined the role of cognitive processes that contribute to the expansion of the knowledge base of students of all ages, particularly executive functions. Krapivina (2022) developed and practiced independent work schedules for students under the new conditions of a hybrid system in higher educational institutions on the basis of foreign experience and in accordance with the methodological requirements and approaches to optimising educational activities. He cites the special role of the teacher in organizing independent work, personalising the language material, stimulating the skills of critical understanding. All the proposed organizational and pedagogical strategies have shown their effectiveness.

We argue that students must master all independent work elements to achieve the desired learning outcomes. By examining the individual needs of students in a genetics class, this study aims to demonstrate that science-based students can benefit from the same skills proposed by Cowan (1978) and Watson and Gallagher (2005) as planning, monitoring, and self-assessment. In this study, we investigated motivations for independent study among Kazakhstan students and high light the role of cultural nuances contributing to academic performance. We sought to determine the effectiveness of the process of developing the genetics knowledge of future biology teachers by organising independent work on the subjects of genetics in a multilingual learning environment.

Research Questions

To resolve challenges faced by students during independent work, the authors developed two research questions:

1. What types of independent work in genetics are most effective for students in the context of multilingual education?

2. What is the impact of the regular use of independent work on genetics in the educational process on the level of achievement?

Methods

The multilingual educational programme has been running since 2015 at Abai University in specialised courses including "5B011300 Biology". The most important requirement for the composition of the educational content of the course under consideration is the requirement that all components of the content comply with the needs of the society. An important area of development of state programmes is the "Roadmap for the development of trilingual education for 2015-2020"(https://online.zakon.kz/document/), which requires the development of teaching aids for integrated teaching of the subject and language. Multilingualism in the educational environment is one of the main aspects of the work of all educational institutions in Kazakhstan.

The study employed a quasi-experimental design with pre-test and post-test measures for both experimental and control groups. The participants were 3rd-year biology students enrolled in a genetics course at Abai Kazakh National Pedagogical University. The purpose of the course is theoretical justification and development of methodological foundations for the development of genetics knowledge of students - future biology teachers, whose methodological training is based on independent work with educational information in the conditions of multilingual education, and experimental testing of the main conceptual provisions in the conditions of educational practice.

The first stage of experimental work was the detection. At the stage of the detection experiment, an analysis of independent work performed in Kazakh and multilingual educational groups of biology specialties was carried out in order to determine the level of the actual state of the problem under study. In the course of the detection, various methods were used: pedagogical, methodological works and scientific and methodological works related to the research topic were analysed, best practices in teaching biology were studied. Thus, in order to determine the actual state of the educational process and the initial level of training at the stage of the detection experiment, a solution to the following tasks were sought. In the training of future biologists in the conditions of multilingual education in higher educational institutions;

1. Determining the quality of the organisation of independent work,
2. Determining the degree of knowledge as a result of the organisation of independent work,
3. Determination of the effectiveness of the modified application of independent work on genetics,
4. Preparation of educational and methodological materials necessary for methodological support of the application of independent work in the discipline "Genetics" in the context of multilingual education.

In the process of solving these problems, a questionnaire (survey) was developed, and tested by researchers were used for data collection The items in the questionary were taken from the intendent literature. The survey conducted at the stage of the detection experiment was the basis for planning the orientation work for conducting the experiment based on the thoughts of students. At the stage of the formative experiment the effectiveness of the methodology for the development of genetic knowledge by organising independent work of future biologists in the conditions of multilingual training was monitored Students in the control groups used such types of independent work as preparing abstracts, essays, presentations, report while in experimental groups - "Quiz", "Matching", "Find the terminology", "True or False", "Semantic map", "Black Box" Activities & Games, "Number Talks", "Brainstorming", "Complete the gaps with the words below"," Active vocabulary", "Try to guess the odd one out" along with these methods, project also were given to the sample.

Model of Organisation of Professionally Oriented Independent Work of Students on the Development of Genetics Knowledge in the Context of Multilingual Education

We sought to determine the effectiveness of the process of developing the genetics knowledge of future biology teachers by organizing independent work on the subjects of genetics in a multilingual learning environment. A sample lesson plan and its implementation about independent work on the subjects of genetics in a multilingual learning environment is presented in Appendix 1. The purpose of the experimental training was to test the effectiveness of the methodology for the development of genetic knowledge based on independent work with educational information in a multilingual teaching environment at a pedagogical university.

At the beginning of the experiment a questionnaire to identify learning problems of students were developed by researchers. In order to develop the questionary (Table 1), an expert group consisting of a professor, 2 doctors of pedagogical sciences, 1 doctor of biological sciences and 2 candidates of pedagogical sciences were studied together All experts have been engaged in scientific and pedagogical activities in their specialty for more than 20 years. The expert group assessed the compliance of each issue with the conceptual structure. The formulation of the questions was based on

the clarity and accessibility of the respondents' perception, with the exception of the use of specific medical terminology and abbreviation. The questionnaire was compiled using single word and multiple choice answers. To measure the reliability of the content, relevance, clarity, simplicity and ambiguity were evaluated on a scale from 1 to 4 points. The calculation of the content reliability index (IDS) was used to assess the relevance, clarity and simplicity of the elements and the overall reliability of the questionnaire content.

For pilot testing, the survey was conducted anonymously, manually on paper. The informed consent of the respondent was attached to each questionnaire, indicating the purpose and procedures of the questionnaire, the benefits of the respondent's participation, anonymity and voluntary participation. The determination of the internal consistency of the questionnaire was based on the splitting method and the calculation of a Cronbach value (Tenkebayeva A. Z., and others, 2019). The questionnaire is considered reliable with an acceptable value of Cronbach's a (>0.6).

Data Analysis

Descriptive statistics were used to analyse demographic findings, as well as for individual questionnaire elements. The reliability of the questionnaires was assessed by analyzing internal consistency. The content and criteria validity were assessed at the questionnaire development stage. The constructive validity was carried out using factor analysis.

Classes with the control group followed a sequence of traditional methods, and in the experimental group a methodological system of teaching genetics was introduced using independent work during one term (see sample lesson plan in Appendix 1)

Data Collection

To determine the readiness of students for independent work and the conditions in the educational process, the survey was conducted including 164 students (see Appendix 2). The survey aimed to assess their study methods and attitudes towards learning genetics.

Data Analysis

To ensure the analysis directly addresses the research questions, we will clearly outline the process and findings. The research questions focused on the effectiveness of the independent study methodology and the specific challenges faced by students in a multilingual learning environment.

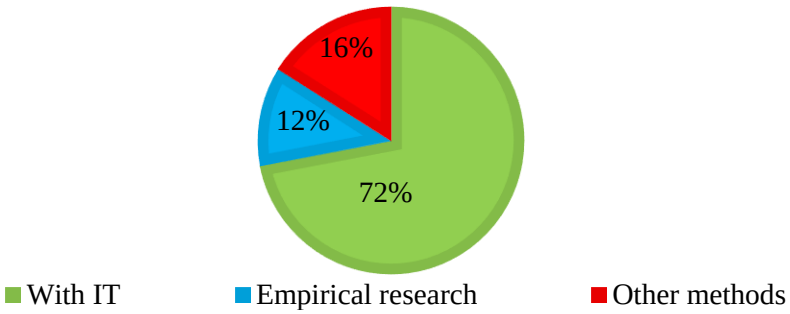
Results

The study was conducted among students majoring in Biology of the 3rd year. The questionnaire sought answers to 12 questions, including questions on the development of genetics knowledge through independent work in a multilingual environment. Table 1 (Appendix 2) shows that 53.6%) of students were familiar with independent study methods. Most of these students (72%, Figure 1) used technologies in their independent studies, while others preferred practical research when resolving their problems. As shown in Figure 2, 39.6% of students stated that they creatively used computer study while the rest relied on verbal guidance from the teacher or laboratory-based practice. Generally, students thought that independent study was the best learning method (48.7 %, Figure 3), contributed to their understanding of theoretical aspects within the genetics field and helped them form habits that would be useful in the future. When asked about the challenges they encountered, 54.8% noted insufficient literature in their native language while others did not have adequate time. To resolve these challenges, 39% of students proposed that lecturers should outline the purposes and tasks of the independent work before starting the program. Other students requested training in software application and organisation skills.

Figure 1 shows the methods used in independent work.

Figure 1

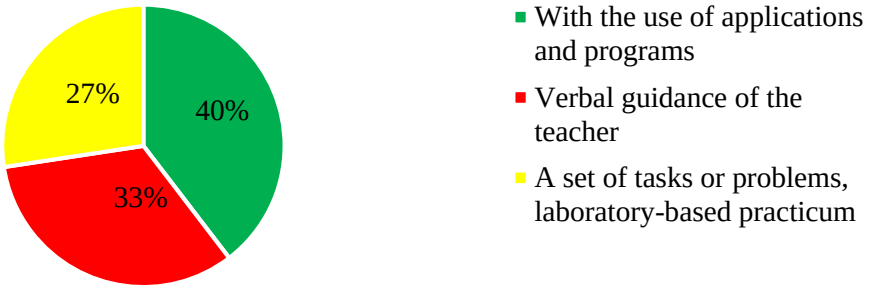
Representation of methods used in independent work



A total of 72% of students used IT, 12% used empirical research, and 16% used other methods.

Figure 2

Independent work preparation methods

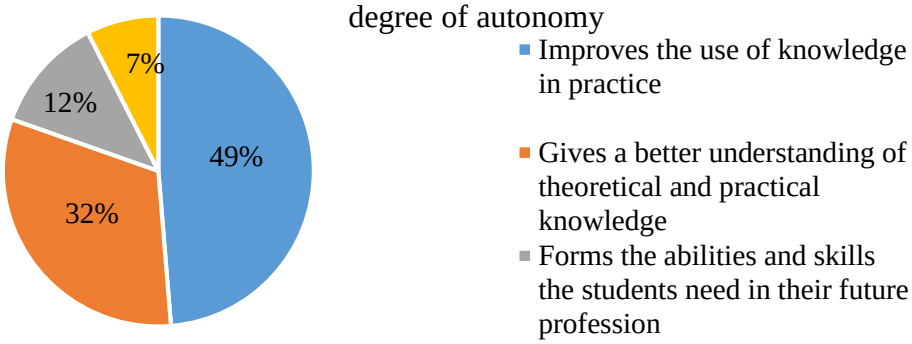


A total of 39.6% of the students worked with applications and programmes, which allowed them to perform an independent study on computers, 33% used verbal guidance from the teacher, and 27.4% preferred laboratory-based tasks.

Figure 3

Autonomy in knowledge development

Figure 3: Assistance from independent work for the increase in the degree of autonomy



A total of 48.7% of students believe that practice is the best way to help them learn, 31.7% believe that it contributes to a deeper understanding of theoretical and practical knowledge of genetics, 12.1% believe that it forms abilities and skills they need in their future profession, while7% chose other.

Research Question 1: What Types of Independent Work in Genetics Are Most Effective for Students in the Context of Multilingual Education?

Based on answers to this question, we learned the general direction of independent work in studying genetics. We considered a rating of 50.1% and above as the majority opinion. However, in cases where the opinion on a particular question was lower than 50% but higher than the percentage of the other answers within that question, we defined this situation as a comparative majority opinion. Based on the results, we found a majority opinion for questions one, two, three, and five. In question one, 91% of the participants preferred attending physical genetics classes, 53.6% viewed independent work as a useful study method, and 72% used information technology for independent study. In addition, 54.8% had challenges finding literature in the Kazakh language.

However, there was a comparative majority opinion from questions six to twelve. For example, 39.6% prefer to use programmes for independent study (see Figure2),39% consider it essential to clearly define the tasks,39% support the idea of methodological guidance for students within the scope of independent study,48.7% think that practice is the best option in education (see Figure3), 42.6% proposed a change in the study content,33.5% chose project-based study as a pedagogical technology, and 46.9% chose the brief assignment method (five to seven minutes) as an independent work control method.

In summary, following the questionnaire data, 33% of the questions revealed a majority opinion and 58% revealed a comparative majority opinion. Therefore, there is a common opinion toward independent study in genetics classes.

Research Question 2: What Is The Impact of The Regular Use of Independent Work on Genetics in the Educational Process on the Level of Education?

The third question in the survey established whether there were questions without a majority opinion. This includes questions to which the researchers did not receive responses. In the study, there were no responses to the fourth question. Consequently, only 1 of 12 questions (0.083%) lacked an opinion. In the course of the study, we compared the learning outcomes of the experimental group with the learning outcomes of the control groups.

To determine the levels of assimilation of genetic knowledge at various stages of the experiment, three cross-sectional control work and a delayed knowledge test were conducted to identify an indicator of the strength of knowledge. The first cut-off was carried out before the start of the experiment in order to identify the current level of knowledge acquisition, the second - after 3 months of experimental training, when students had hopefully mastered the necessary knowledge and skills base, the third - immediately after the completion of the experiment.

An important requirement for the structure of the educational content in the conditions of multilingual teaching of biology students at a pedagogical university is the requirement to observe the logical connection of its components. Therefore, the course "Genetics" is designed in such a way that at the first stage of teaching genetics, the patterns of heredity are studied, which provide important knowledge and practical skills. At the second stage, information on variability, molecular genetics, population genetics, human genetics, and the breeding foundations of genetics is studied.

As an educational content structured in accordance with the idea of multilingual education for students at a pedagogical university, consider the discipline "Genetics". The content of the genetics course for students of the English group of the specialty 5B011300–Biology "Cytological basis of sexual and asexual reproduction", "Regulations of heredity", "Gene interactions", "Sex-linked inheritance",

"Linked genes and crossing over", "Classification of variability", "Molecular genetics", "Population genetics", "Human and medical genetics", "Genetic basis of selection". The following methods were used in organising independent work for students based on these topics: "Quiz", "Matching", "Find the terminology", «True or False», «Semantic map», «Black Box» Activities & Games, «Number Talks», «Brainstorming» «Complete the gaps with the words below» «Active vocabulary», «Try to guess the odd one out» and etc. In independent work, the results of research related to methods that are effectively used in foreign and domestic methods are used. These methods allow you to develop genetic knowledge. The results of systematically organized independent work will help to get a quality education in genetics. The organization of independent work of students, diverse in purpose and content in the course of the development of genetic knowledge, contributes to increasing their subject knowledge.

Research work on the development of genetic knowledge through the organization of independent work in the context of multilingual education for students showed that they are interested in performing independent work in the direction of digital education in the course of conducting questionnaires. In this regard, the following platforms were used for independent work in the process of genetic education: crossword - https://childdevelop.info using the site, rebus generator rebus1.com, test generator online test pad (https://onlinetestpad.com/ru)
cross puzzle generator (http://cross.highcat.org/ru),Interactive whiteboard: okulyk.com " performs tasks, padlet board https://ru.padlet.com/.

All topics can be presented by preparing and presenting various independent works. Only students made their own choice and completed the tasks at their discretion. Also, when performing tasks, new programs (google slides, prezi, zoho show, powtoon, canva, wordwall, xmaind) used timeline, etc.

To determine the level of development of genetic knowledge among students, we developed control sections of knowledge at the ascertaining stage on the topic “Laws of Heredity”, and upon completion of the “Genetics” course at the formative stage of the experiment - on the topic “Selection Fundamentals of Genetics”. Processing of the obtained results was carried out on the basis of quantitative and qualitative analysis of the data obtained. To quantitatively assess the development of genetic knowledge in multilingual student conditions, we used the coefficient of knowledge assimilation, and for a qualitative assessment we determined the properties of genetic knowledge, its completeness, strength, quality and consistency. To identify the development of the student’s genetic knowledge, we compared the research results at the initial and final stages of the experiment.

In diagnostics, we will apply three levels of knowledge acquisition: algorithmic, heuristic and creative.

Level I - "algorithmic" is the solution of tests based on the knowledge available to students - a reproductive algorithmic action to solve a problem based on the application of a previously learned action, rule or algorithm to solve it.

Level II - "heuristic" is a productive action performed not according to a ready-made algorithm or rule, but during the independent transformation of a known basis of previously learned actions. In the process of completing a task, the student discovers subjectively new information and applies it to solve an atypical task. For example, tasks for analysis, for comparison

Level III - "creative" is a productive activity of a creative type, in which a suitable situation and actions are searched for to create objectively new, previously unknown information on the basis of learned information, leading to the achievement of a goal. If the task is, for example, to violate the splitting formula.

As a means of determining the quality of assimilation, Bespalko suggests using specially designed tests. The test consists of a task for the activity of this level and a standard, i.e. a sample of the complete and correct execution of the action. According to the standard, the number of significant operations (p) leading to the solution of test tasks is determined.

Comparing the student's response with the standard in terms of the number of correctly performed operations (a) of test tasks makes it possible to determine the coefficient of assimilation (Ka). The determination of Ka is an operation to measure the quality of assimilation. The coefficient of

assimilation is amenable to normalisation (0<Ka<1) and is compared with any rating scale. According to the coefficient of assimilation, the completeness of the learning process is judged: at Ka > 0.7, the learning process can be considered completed, since in subsequent activities the student is able to improve his knowledge during self-study. If the coefficient of assimilation does not reach the level of 0.7, then the student makes systematic mistakes in subsequent activities and is not able to correct them.

Based on the methodology for determining the levels of assimilation of concepts according to Bespalko, we have developed criteria for evaluating students' knowledge, which include the following levels:

The first level is the answers of students in which there are inaccuracies. The presence of specific correct examples combined with the absence of any explanations. The second level is answers in which students reproduce some single aspects of concepts, but do not transfer essential facts to other objects. The third level consists of answers in which students correctly formulate concepts, but do not provide examples and explanations. The fourth level consists of answers in which students competently apply concepts and terms, give various examples, mark and characterize the essential aspects of objects and phenomena.

Knowledge qualities:

• completeness - the amount of knowledge acquired in accordance with the program about the studied object, phenomenon or process,

• depth - the number of learned connections between related knowledge, components of a particular system, and their functions,

• variability - the ability to apply knowledge in different situations,

• flexibility - the ability to apply knowledge in a changing environment,

• concreteness and generality, convolution and unfoldment - the ability to use plans, theses, diagrams, linguistic methodological apparatus of textbooks and teaching aids,

• consistency, strength, awareness, reflexivity - understanding the nature, ways of obtaining and assimilating knowledge, the connections between them, the value of knowledge and the ability to prove their truth from the standpoint of science,

• a value-oriented and motivationally based attitude to education, i.e. the motivation for obtaining knowledge with an internal orientation towards the value of knowing reality - the laws of nature and society,

• intellectual orientation towards the processes of adaptation to the conditions of nature and society,

• humanism and humanitarianism,

• orientation in the information paradigm of science, culture, etc.

The results of the pedagogical experiment confirmed the effectiveness of the proposed methodology based on the consistent development of knowledge in the course of genetics in a multilingual learning environment and showed the following: at the initial stage of the development of concepts, their assimilation was at a relatively low level. This is due to the fact that at the initial stage of knowledge development, students were required to acquire knowledge in secondary education. As an example, we present the results of mastering knowledge at the initial stage (Table 2).

Table 2

Students' genetics knowledge based on the results of testing at the initial stage

Groups	Number of students	Results				
		61-69%	70-85%	86-89%	90-94%	95-100%
Control group	84	24	27	20	8	5
Experimental group	80	7	12	21	26	14

Current state of students in the discipline" genetics" criterion-based assessment of training results high, at k = 91 to 100%; sufficient, at k = 71 to 90%; medium, at k = 51 to 70%; weak, at k = up to 50%. During the pedagogical experiment, it turned out that acknowledge develops, its scope expands, and its content deepens, the quality of learning about the patterns of inheritance of the experimental groups becomes higher than in the control groups.

A significantly larger number of students in experimental groups than in control groups established the interrelationships of concepts, assimilated the most complex genetic concepts related to the disclosure of the mechanism of processes and phenomena (Table 3).

Table 3

Students' genetics knowledge based on the results of the final test

Groups	Number of students	Results				
		61-69%	70-85%	86-89%	90-94%	95-100%
Controlgroup	84	22	24	25	5	8
Experimental group	80	4	15	24	20	17

As a result of the study, it can be said that the increase in the level of knowledge of students in the experimental group compared to the control group is the result of their better mastery of the subject of genetics in the context of multilingual education. The problem of the development of genetic knowledge, which we are considering, is one of the most important disciplines for students studying in the specialty biology. From the point of view of mastering the same discipline in multiple languages, it expands access to additional information for students at a Pedagogical University, develops linguistic and didactic practice, and also has a great place for independent work, which contributes to the development of knowledge in genetics and the formation of an educated specialist. For the development of genetic education, it is necessary to master and apply in our own practice active methods of the content of domestic and foreign education in the context of multilingual education.

Discussion, Conclusion and Recommendation

This study investigated the impact of independent work methodology on genetics students at Abai Kazakh National Pedagogical University, within a multilingual educational context. The findings provide valuable insights into promoting independent learning among students in a multilingual environment.

Key Findings and Their Implications: Formulating Personalized Learning Paths: The study demonstrated that students could effectively formulate their own learning strategies within the framework of the "reference community" model (Harrison, 2011). This model supports collaborative learning and allows students to engage with peers and instructors both online and offline. The findings align with previous research, which emphasized the benefits of independent learning and personalized educational trajectories (Abulkhamitovna et al., 2014; Abishova et al., 2020; Andreeva et al., 2020; Argode et al., 2017; Azimov & Shchukin, 2009; Fidik, 2017; Hawk, 2011; Hayes, 1999; Lou & Lin, 2018).

Students highlighted the importance of having autonomy in their learning processes while also recognizing the value of teacher-led research guidance. This dual approach can enhance the depth and quality of independent work by providing a structured yet flexible learning environment.

Challenges in Multilingual Education: One of the significant challenges identified was the difficulty students faced in accessing and comprehending materials in English. Despite the multilingual setting, the scarcity of English-language resources on genetics posed a considerable

hurdle. This challenge underscores the necessity for a robust database of educational materials and technical terms in multiple languages, particularly English, to support independent study effectively.

Recommendations for Practice

Development of Multilingual Resources: Create and maintain a comprehensive database of genetics literature and technical terms in English and other relevant languages. Develop textbooks and teaching aids in English to bridge the resource gap and facilitate independent learning. Encourage teachers to incorporate independent study modules into their teaching practices, offering guidance while promoting student autonomy.

The results of this study showed that the use of independent work in a multilingual environment significantly improved achievements in the study of the subject of genetics compared to students who studied these topics in genetics using traditional teaching methods. The study showed that students' academic performance after the intervention was significantly higher than before it. Most of the students of the experimental group answered correctly on the final test than from the control group. This result confirms the results of the study. This confirms the conclusions that the effectiveness of learning using traditional learning styles is minimal. It was found that most students easily use different digital methods in independent work.

Limitations and Future Directions

Our goal was to create awareness of independent working undergraduate students undertaking biology and genetics courses. Independent work is beneficial to students as it provides an advantage over other students and extends their knowledge beyond their academic scope (Abishova et al., 2020; Andreeva et al., 2020). Therefore, promoting independent study among undergraduate students in Kazakhstan is beneficial to students, lecturers, and practitioners. However, this study had limitations that could be explored in the future. For instance, the study had only 164 participants. The results from other studies may be influenced by their research design (longitudinal study or experiment). However, these study findings lay a foundation forthe needs of students, and future studies may use these opinions to enhance the generalizability. Most studies exploring this phenomenon have either been teacher-focused (Buma & Nyamupangedengu, 2020; Singer & Smith, 2013) or student-focused (Al-Otaibi, 2019; Briede & Popova, 2020; Burns et al., 2020; Cowan, 2020). However, the community inquiry framework (Garrison, 2011) advocates for a teacher-led independent study. Overall, students are considered partners in the learning process through independent study, which emphasizes that teachers are peers (López-Pérez et al., 2011; Peacock & Cowan, 2018). Therefore, a survey from a single source (students) eliminates the contribution of the lecturer. Future research should simultaneously engage lecturers and students to enhance the accuracy of the phenomena under study.

Answers to some questions of the questionnaire are missing. The lack of answers can be explained by the ambiguity of the question. Research shows that the researcher's task is to ask non-deductible and relevant questions with sufficient information to ensure that participants provide appropriate answers (Legaspi & Henwood, 2017). Therefore, future research should explore other ways to adequately ask this question in order to get an answer. Finally, these results provide the basis for the development of constructs and variables that can be scientifically proven. Although the study includes a series of questions that reflect the three elements of independent research, planning, observation, and self-esteem, future research should clarify variables for convenient replication in other studies.

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Appendix 1

Lesson Plan: "Human Genetics and Research Methods"

Lesson topic: Human genetics and research methods.
The purpose of the lesson: to consider the inheritance of human genetics traits
The content of lesson: "Human genetics".
Slide 1: "Human chromosome set",
Slide 2: "The pedigree of the Victoria family"
Slide 3: Classification of hereditary diseases
Teaching methods and techniques:
Verbal (story), visual (working with pictures), working with a textbook.
Equipment: interactive whiteboard, multimedia presentation, printouts of tasks on genetics
Taching steps:
1. Problem statement;
2. Table analysis "Methods of human genetics research";
3. Analysis of the Human Chromosome Set table;
4. Consideration of the inheritance of traits in humans
5. Consideration of chromosomal abnormalities and their causes;
6. Tasks for the compilation and analysis of pedigrees; twin methods
7. Online Shezhire (genealogy-in English) analysis or Pedigree in "digital". Mobilaser.kz
8. Solving problems of inheritance of pathological genes;
9. Independent work of students;
10. Reflection
The teaching process of the lesson:
I part of the lessons: Teacher's conversation with students:
• poses specific questions (for generalization, justification, concretization, logic of reasoning);
II part of the lessons: Explanation of the teacher with new materials for the student (Updating knowledge):
III part of the lessons: Solving the problem of students' independent work
Preparation of reports on the topic "Methods of studying human heredity":
• genealogical;
• twin;
• cytogenetic;
• Biochemical;
• immunogenetic.
Independent compilation of genetic tasks: Introspection
Reproductive:
• reproduction of the material covered;
• solving problems according to the algorithm.
Reconstructive
• with a diagram on the board (comparison, generalization);
• solving the problem of applying knowledge in an unfamiliar situation (creating family trees with different platforms).
Productive activities:
• Preparing messages;
• compilation of genetic tasks (homework);
IV part of the lessons: Reflection and homework.
activity reflection sheets are used
- I remember the most about the lessons...
- I was surprised that...
- I would also like to know...
- I can use the knowledge gained in classes in...
- I worked best in classes...

Appendix 2

Table 1: Findings of the Survey on Independent Study in Genetics

Question	Response (%)
1. Do you like genetics as a science and academic subject?	91
2. How effective is the independent educational work of students as a tool for the development of expertise in genetics?	53.6
3. What is your favorite type of independent study?	72
4. Where did you conduct the independent study?	N/A
5. What prevents you from doing the independent study? -Lack of literature	54.8
-Lack of time	14
6. What are your favorite methods for self-preparation within the independent study? -Application programs	39.6
-Verbal guidance	33
-Laboratory-based experiments	27.4
7. What conditions can help increase the degree of independence during genetics classes? -Purpose and task have to be clear	39
-Learning how to use software	28.6
-Organization skills and self-motivation	17.6
8. What is the best method for organizing an independent study? -Methodological guidance	39
-Computer equipment	27.4
-Class and out ofclass study	19.5
9. What is the role of multilingual education (education in different languages) in a pedagogical university within genetics classes? -Learning methods	48.7
-Theoretical and practical expertise	31.7
-Formation of ability and skills	12.1
10. How possible do you think it is to improve genetics classes taught in a foreign language? -Change content	42.6
-Design classes in a foreign language	25
-Use of technology and simultaneous interpretation	15.2
-Strengthen teacher control	9.1
11. Choose the pedagogical technologies that you think are the most effective for organizing multilingual independent studies in genetics. -Project-based learning	33.5
-Problem-based learning	12
-Reflexive learning	7.9
-Development of critical thinking methods	6.7
-Research work organization	43
-Group discussions	6
-Case technology	1.8
-Game-based technology	6
12. What is the best type of control for an independent study? -Brief assignment method with test cards	46.9
-Present independent study in the form of multimedia presentations	19.5
-Check test and exam results	7.9
-A control system including all control types in the discipline	12.1
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