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An Environmental Approach to Developing and Applying Smart Complexes of Academic Disciplines in Professional Training of Future Specialists

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Abstract: The paper discloses modern approaches to creating integrated information environments of SMART complexes of academic disciplines through integrating creative, authorial, non-verbal, encyclopaedic, information-and-communication, self-realization, self-assessment components in professional (vocational) and pre-university professional education. It lists the advantages of such complexes compared to e-textbooks and reveals the requirements for developing them. It highlights the ways of considering future specialists' psycho-physiological development when selecting and structuring educational information. It recommends applying constructive equalization of students' cognitive activity based on the Kosko's quasi-neural network model in their designing an educational trajectory. It shows conditions for ensuring equal opportunities for students' learning within such complexes. Both selection and structurization of such complexes' educational information follow students' psychological development in perceiving it and focus on critical feature patterns of the adaptive resonance theory and the Hopfield model for associative memory. The paper suggests evaluating students' activities within such complexes by comparing each participant's achievements with the parameters of completed projects, using the index method based on qualimetric measurements. It specifies the features of an environmental approach in developing such complexes; elaborating their educational material; determining types of learning tasks; creating means of monitoring students' knowledge. It justifies the results of experimental work, which involved surveying 442 teachers and analyzes the influence of such complexes on the effectiveness of the educational process. It highlights the importance of introducing heuristic forms, methods and techniques of students' learning to help students obtain, systematize and consolidate educational information and acquire practical skills in performing creative projects and professional tasks.

Keywords: *SMART complexes of academic disciplines; integrated information environment; environmental approach; model of Kosko's quasi-neural network; professional education; teaching staff.*

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1. Introduction

1.1 Problem statement. The National Strategy for the Development of Education in Ukraine for the period till 2021 defines its informatization as one of the important areas of education reform. It means the introduction of modern information and communication technologies (ICTs) that can improve the educational process, contribute to education's accessibility and efficiency, as well as enhance the training of younger generations for life in the information society. In view of this, there appears to be a need for systemic changes in professional education, which prepares qualified personnel for industry, agro-industrial complex, construction, trade, catering, services, transport, housing and communal services, telecommunications. At the same time, the level of future specialists' training in professional education schools (PE schools) does not fully meet the needs and requirements of the modern labour market. This is evidenced by the results of monitoring the level of future specialists' training, their employment, as well as the requirements of employers, representatives of local authorities and the public for the quality of professional education. In this regard, it is important to justify an environmental approach to developing and applying SMART complexes of academic disciplines in professional training of future professionals, which can help to increase their professional competency and mobility in the labour market.

1.2 Analysis of recent studies and publications. The implementation of an environmental approach is facilitated by modern ICTs and e-learning, which make it possible to update SMART education. This particular problem has repeatedly attracted the attention of Ukrainian scholars and practitioners. Indeed, Hulchii et al. (2018) justify the use of SMART technologies in the context of updating the educational process. They analyze the possibilities of their influence on enhancing students' cognitive activity, developing a communicative culture in the student-student and student-teacher systems, disseminating individual vitagenic and professional experience in the educational process, as well as their role in the adaptation of the educational process to the needs and requests of those engaged in learning. At the same time, they reveal the algorithm of developing and improving specialists' information and analytical competency using SMART technologies.

The introduction of information and educational environment in vocational education institutions provides individualization and profiling of the educational process and promotes the development of information competence of teachers based on their study of the course "Creation and use of electronic educational resources"(Radkevych 2018). Klochko & Mykhaylyuk (2018) describe e-learning complex development with possibilities of a user's (teacher) discipline content forming and development block, based on intelligent data mining algorithms, a training block simulation model, meta- disciplinary electronic resources. M. Pryhodii (2019) has disclosed that due to the use of SMART-complexes, operational interventionin the structure of the work program with the consideration of the individual characteristics of participants in the educational process becomes possible.

Those studies devoted to the role of ICTs in ensuring education informatization and learning individualization, as well as methodical approaches to their implementation in pedagogical activities, are important to the development and application of electronic educational resources in the educational process (Humenniy & Radkevich, 2017). However, the problem of developing and using SMART complexes of academic disciplines remains a rarely studied phenomenon. Therefore, it is essential to justify the use of an environmental approach to their development and use in professional training of future specialists in PE schools.

Problems of future competencies development have highlighted by Voinea (2019), Voloshenko et al. (2020). The use of information technology in education was investigated by Mâţă & Boghian (2019), Ghiatau & Mata (2019). Features of distance learning students revealed by Lazar & Faciu (2019), Santi et al. (2020), Dushkevych et al. (2020), Bran & Grosseck (2020).

1.3 The paper aims to reveal the peculiarities of an environmental approach to developing and using SMART complexes of academic disciplines in professional training of future specialists.

2. Theoretical framework of research

The importance of ICTs in the context of providing full-time and part-time education and distance learning is increasing, given the current modernization of professional education, including online technologies. Depending on the level of using online technologies, there is a distinction between traditional training, traditional learning with web support, blended learning, full-time online learning (80% of it organized in the form of distance learning) (Li et al., 2013). The documents of the Ministry of Education and Science of Ukraine also touch upon the need to implement educational programmes using e-learning tools and distance learning technologies. Thus, the National Educational Digital Platform Concept focuses on expanding access to free high-quality e-textbooks and other online educational resources for students, launching the national production of electronic educational resources and enhancing the flexibility of an educational environment.

SMART complexes of academic disciplines, unlike the electronic textbook with the acronym SMART, have the following advantages:

- they enable the introduction of techniques and ways of developing logical, creative and balanced thinking during the educational process with the impact on the three areas of the cerebral cortex (effective, distinctive and strategic), which have been much studied by CAST scientists (Meyer et al., 2014); such an organization increases students' activity;
- they make it possible to adhere to the constructive alignment principle developed by J. Biggs for students' development (Biggs, 2001); it increases their responsibility for learning;
- they contribute to making a creative environment following the model of Kosko's quasi-neural network (Kosko, 1987), based on Grossberg's adaptive resonance theory (Grossberg, 2018) and the models of Hopfield auto-associative memory (Hopfield, 1982);
- they enhance the organization of an encyclopaedic environment with the observance of Dublin Core Metadata Initiative) to describe its scientific foundations. This facilitates the unification of metadata to describe the widest range of information resources;
- they ensure interaction between the developers of SMART complexes of academic disciplines and teachers from PE schools in the author environment.

SMART complexes of academic disciplines provide equal opportunities for students' learning activity and are developed following the requirements of three main approaches: presentation (different styles of learning activity are offered; opportunities for obtaining and systematizing information and supplementing knowledge and are provided); actions and statements (learning opportunities are provided to demonstrate learning outcomes); interaction (students' motivation towards learning is boosted by creative learning tasks, projects). It is essential to follow certain requirements when developing such complexes. They include compliance with education standards; an organic combination of hypertext and multimedia information; the complementarity of real and virtual presentation of educational information in an integrative information environment; regulation of the components of an integrative information environment (students can change them, access educational information, test their knowledge, organize and consolidate it since SMART complexes of academic disciplines can be constantly expanded and updated).

It is vital to take into account how students perceive educational information of SMART complexes of academic disciplines following their psycho-physiological development (effective, distinctive and strategic areas).

The effective area (learning content) aims to provide students with the main educational information, as well as additional information on the completion of learning projects following the principle of constructive alignment (Kosko, 1987). In this regard, the content, forms and methods of students' learning activity, as well as methods of analyzing and assessing learning outcomes are mutually consistent and aimed at optimizing the conditions for stimulating their cognitive activity. The requirements of constructive alignment are met by taking into account the differences between the constructivist understanding of didactics and designing of an integrative information environment, which enables students to construct their learning trajectory according to their learning tasks and educational perspectives.

The distinctive area involves students' application of various learning methods and techniques, including creative ones and the provision of several options for searching and synthesizing educational information as an alternative to demonstrating the acquired knowledge.

The strategic area (learning forms, methods and technologies) ensures the integration of methods, techniques and ways of students' learnings aimed at boosting their motivation towards completing project (learning) tasks.

The analysis of scientific works Hulchiy et al. (2018) and empirical experience of the authors of the paper shows that the development of SMART complexes of academic disciplines consists of several stages: analyzing, designing, implementing, validating and verifying (Humenniy & Radkevych, 2017). The features of an environmental approach are identified at the designing stage, namely, in the structural construction of an integrative information environment, in the general scenario for developing SMART complexes of academic disciplines, in the selection of information and logical content of educational material based on an integrative information environment, in the determination of types of learning tasks with self-actualizing and creative environments, in the designing of ways for control and self-control of knowledge in a self-evaluative environment, in the creation of an interface and navigation using information and communication environment.

The creative environment (a component of an integrative information environment) ensures the variability of educational material and can improve during learning activity of students as its participants who become the designers of their quasi-professional activity and professional training as a whole: they make lesson plans, express their personal views on key problems in the development of learning projects, become independent and responsible. This component is related to *the self-assessment environment* in which learning activities are performed based on expected learning outcomes, and all components of the curriculum are aimed at enhancing students' cognitive activity. Assessment tools and instructional strategies are consistent with learning outcomes since it involves modelling students' goals, values and the meaning of development that takes place with their direct involvement in learning projects.

The author environment takes into account the features of P(V)E schools and professional pre-university education institutions, certain specializations students acquire, their motivation towards learning activity, as well as the introduction of additional educational materials in an integrative information environment.

The non-verbal environment allows one to apply methodical and psychological techniques of virtual presence of teachers in an integrative information environment. Such present can involve performing the roles of an online platform manager (reproductive performance of do-it-yourself tasks; online counselling) and an Internet surfing instructor (tasks for developing critical and logical thinking, media literacy; acquiring the culture of network security; using non-threatening online resources).

The self-realization environment is created based on the principle of an architectural structure of Kosko's quasi-neural network (the number of inputs and outputs of the quasi-neural network corresponds to the number of proposed projects, recommendations, proposals, comments and positive integers undetermined in the field, which is why the authors of the paper refer them to a fuzzy set) (Kosko, 1987) (see Figure 1); the principles of Grossberg's adaptive resonance theory, whose critical concepts are critical feature pattern (Grossberg, 2018); the models of Hopfield auto-associative memory (Hopfield, 1982). The weight matrix, as an important component of the quasi-neural network, is associated with the assessment of student performance to develop learning projects by comparing each participant's performance with the parameters of completed projects using the index method that can determine the level of each student's impact on a particular project based on qualimetric measurements (the impact weight $\beta_{i,j}$ and the weight matrix W^t).

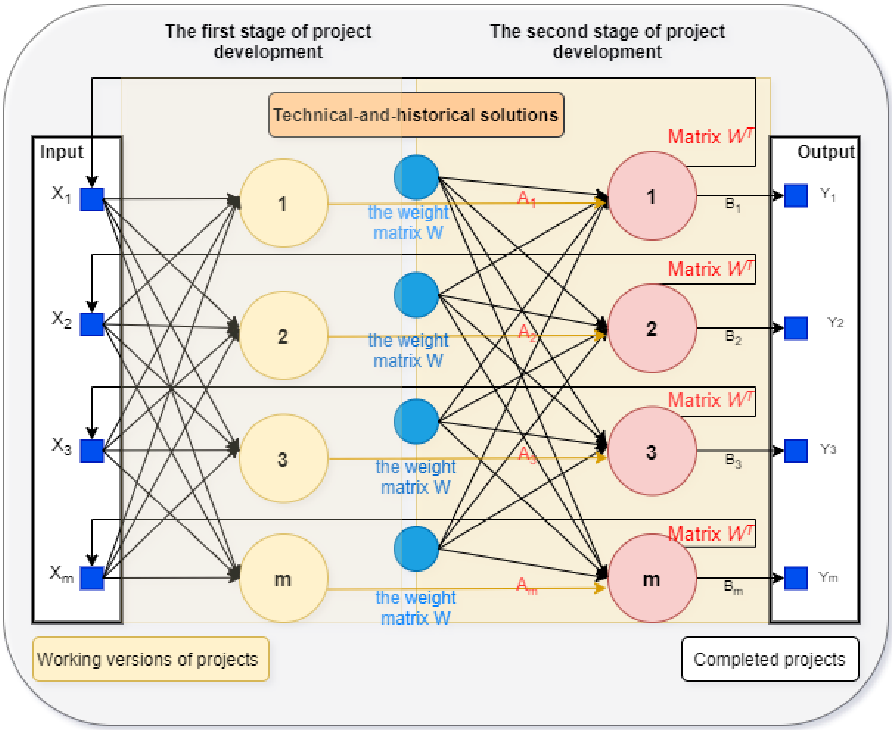

Fig. 1. The model of Kosko's quasi-neural network in SMART complexes of academic disciplines (developed by the authors of the paper), where x_i implies the proposed project topics and y_i – the already completed projects

The model of Kosko's quasi-neural network means creating projects using synergies (when two or more factors interact, their effects significantly outweigh the impact of each of them). When lightweight offerings are overlapped by heavyweight ones, students achieve higher results in the framework of achieving correctly defined learning goals and achieve self-realization in project activities based on their potential.

The self-realization environment implements diagnostic, teaching and monitoring functions. The diagnostic function involves identifying the level of students' educational attainment, revealing the causes of any emerging difficulties, identifying gaps in knowledge and skills, tasks' content and methods of their assessment. The teaching function promotes students' self-evaluation of their learning results. The monitoring function includes identifying the level of students' educational attainment, which enables teachers to plan and adjust their teaching activity, choose optimal technologies, tools and methods for students to master educational material.

The information and communication environment makes it possible to take into account Internet resources while developing SMART complexes of academic disciplines, which directly or indirectly affects the functioning of nerve cells, forcing the human brain to evolve (Hopfield, 1982). In Psychonomic Bulletin & Review, Rohrer & Pashler (2003) in their paper titled "Concurrent Tasks Effects on Memory Retrieval" prove that searching for information on the Internet stimulates human brain activity. At the same time, such tasks negatively affect memory in the case of the multitasking search.

SMART complexes of academic disciplines also use ICTs to enable students to acquire new knowledge following their learning progress. Technological capabilities of freeware and shareware, including NeoLMS, Google Docs, Microsoft online, Foxit Reader, Fotor, Audacity, Bleander3D, OBS Studio, My TestEditor, Pain Net, play a leading role in the development of SMART complexes of academic disciplines. It is vital to maintain the optimality of information load on students while developing SMART complexes of academic disciplines. It allows them to focus on the information they need, causing the movement of peripheral information beyond the interface and increasing amount of information to choose independently ("a quiet technology").

3. Research methodology

The research was conducted following the research programme of the Institute of VET of the NAES of Ukraine, titled "Methodical Principles of Developing SMART Complexes for Training Skilled Workers in Such Fields as Agriculture, Construction and Machine-Building".

3.1 Research methods are the following: theoretical methods – systematization and comparison of scientific views; systemic and logical, analysis of results and modelling: assessment of the results obtained from implementing a heuristic approach to expanding the informational background of the lesson and improving the access to educational information, using the model of Kosko's quasi-neural network in the educational process, assessing the effectiveness of constructive alignment in the implementation of control/self-control of educational attainment; empirical methods: observations, questionnaires, interviews, conversations.

4. Results

The experimental work, which took place between 2017 and 2019 at the premises of such PE schools as Kryvyi Rih Centre of Vocational Education in Metallurgy and Mechanical Engineering, Odesa Higher

Vocational School of Trade and Food Technologies, Lviv Automobile and Road College of National University "Lviv Polytechnic", Bilhorod-Dnistrovskyi College of Natural Resources Management, Construction and Computer Technologies, Bilhorod-Dnistrovskyi Marine Fish Industry College, was aimed at testing the impact of the components of an integrative information environment on the effectiveness of the educational process. It involved 442 teachers. They were surveyed to summarize the experience of implementing heuristic forms, methods and techniques for expanding the information background of the lesson and improving the access to educational information, the expediency and effectiveness of using the model of Kosko's quasi-neural network to facilitate students' creative self-realization, the effectiveness of pedagogical activity in the organization of control/self-control of their educational attainment.

The research finds that heuristic tasks containing the components of internal and external dialogues can first pose a problem to students. However, students start thinking more creatively once they have been clarified to them. The dialogue between students and the teacher in the process of completing such tasks facilitates students' understanding of them in different contexts, reinforce students' learning activity with emotions and values and enables them to use their experience (see Table 1).

Table 1 The distribution of teaching staff by the results obtained from assessing the implementation of a heuristic approach to expanding the informational background of the lesson and improving the access to educational information (number,%)

Features		Does the introduction of a heuristic approach contribute to	
		expanding the informational background of the lesson	improving access to educational information
Age	under 30 years old	31, (17.0)	48, (18.5)
	30–40 years old	54, (29.7)	74, (28.5)
	41–50 years old	46, (25.3)	56, (21.5)
	over 50 years old	51, (28.0)	82, (31.5)
Subjects taught	natural and mathematical	53, (27.2)	62, (25.2)

Features		Does the introduction of a heuristic approach contribute to	
		expanding the informational background of the lesson	improving access to educational information
	sciences		
	general professional subjects	49, (25.1)	66, (26.7)
	social sciences and humanities	36, (18.5)	48, (19.4)
	specialized subjects	57, (29.2)	71, (28.7)
Teaching experience	0–3 years	64, (32.8)	73, (29.6)
	4–10 years	41, (21.1)	74, (30.0)
	11–20 years	58, (29.7)	66, (26.7)
	over 20 years	32, (16.4)	34, (13.7)

Most teachers in PE schools believe that implementing a heuristic approach helps to improve students' perceptions of educational information. Within the framework of this research, it was important to use the model of Kosko's quasi-neural network to analyze the results of constructive alignment of students' educational attainment, to clarify their interconnection at the level of perception, cognitive and professional activity, as well as to take into account psycho-pedagogical features that require the teacher's reflection, as well as his or her ongoing and active involvement in the process. It can give positive results if it is constructed methodically and the participants in the educational process interact share experience.

The study on the use of this model involved teachers who differ in age, duration of teaching experience and subjects they teach, which confirms the representativeness of the sample (see Table 2).

Table 2. The distribution of teaching staff by the results obtained from assessing the effectiveness of using the model of Kosko's quasi-neural network (number, %)

Features		Do you consider learning with the use of Kosko's quasi-neural network more effective than traditional learning?	
		No	Yes
Age	under 30 years old	18, (16.4)	61, (18.4)
	30-40 years old	26, (23.6)	102, (3.,7)
	41-50 years old	29, (26.4)	73, (22.0)
	over 50 years old	37, (33.6)	96, (28.9)
Subjects taught	natural and mathematical sciences	15, (20.5)	100, (27.1)
	general professional subjects	14, (19.2)	101, (27.4)
	social sciences and humanities	12, (16.5)	72, (19.5)
	specialized subjects	32, (43.8)	96, (26.0)
Teaching experience	0-3 years	32, (29.9)	105, (31.3)
	4-10 years	27, (25.2)	88, (26.3)
	11-20 years	32, (29.9)	92, (27.5)
	over 20 years	16, (15.0)	50, (14.9)

Using SMART complexes of academic disciplines involves certain control, that is, the system of testing the effectiveness of the educational process, thereby providing external and internal feedback (student self-control). Therefore, it is necessary to review its content, approaches to selecting forms and methods of pedagogical activity following the principle of constructive alignment (see Table 3).

Table 3. The distribution of teaching staff by the results obtained from the impact of constructive alignment improves the effectiveness of control or self-control of students' educational attainment (number, %)

Features		Do you believe that the impact of constructive alignment improves the effectiveness of control or self-control?	
		No	Yes
Age	under 30 years old	11, (13.8)	68, (18.8)
	30-40 years old	15, (18.7)	113, (31.2)
	41-50 years old	23, (28.8)	79, (21.8)
	over 50 years old	31, (38.7)	102, (28.2)
Subjects taught	natural and mathematical sciences	4, (12.1)	111, (27.1)
	general professional subjects	9, (272)	106, (25.9)
	social sciences and humanities	5, (15.2)	79, (19.3)
	specialized subjects	15, (45.5)	113, (27.7)
Teaching experience	0-3 years	20, (25.3)	117, (32.2)
	4-10 years	8, (10.1)	107, (29.5)
	11-20 years	27, (34.2)	97, (26.7)
	over 20 years	24, (30.4)	42, (11.6)

Most teachers in PE schools believe that following constructive alignment helps to increase the effectiveness of control/self-control of the results of students' educational attainment.

This research also attempts **to justify the results obtained from identifying** professional competency levels in future specialists based on the following criteria and indicators: the values-based and motivational criterion (professional interests – an interest in a particular profession and production technologies; professional needs: – to gain a profession to gain employment, to strive for professional development; professional motives: to gain a profession, to continue learning), the innovative-and-cognitive criterion (general professional knowledge about the fundamentals of production, computer technologies, the fundamentals of entrepreneurship, labour safety, professional terminology; technological (professional) knowledge about material science, production process technologies, scientific organization of the workplace, repair works).

The data of the ascertaining stage of the experiment were summarized and the statistical indicators of CG and EG statistical indicators were analyzed while identifying professional competency levels in future specialists (see Table 4).

The distribution of future specialists by the level of professional competency in CG and EG at the ascertaining stage of the experiment did not differ significantly ($\chi^2 = 0.270$) at the level $\alpha = 0.05$, which indicates the homogeneity of the sample.

The analysis of the results obtained at the ascertaining stage of the experiment prove that most students (58.33% in CG and 56.02% in EG) have low professional interests in their future profession and production technologies. At the same time, 52.27% of CG students and 53.93% of EG students are at a low (consumer-related) level of professional motives (to gain a profession, to continue learning).

Thus, the indicators of professional competency levels in future specialists summarized at the ascertaining stage of the experiment based on the innovative-and-cognitive criterion in CG and EG have slight deviations (see Figure 2).

Table 4. The results obtained from identifying professional competency levels in future specialists (at the ascertaining stage of the experiment)

Indicators	Groups	Levels						χ^2
		Low (consumer-related)		Average (generative)		High (productive)		
		Number of students	%	Number of students	%	Number of students	%	
The values-based and motivational criterion: professional interests – an interest in a particular	CG	231	58.33	88	22.22	77	19.45	0.429
	EG	214	56.02	89	23.30	79	20.68	

profession and production technologies								
The values-based and motivational criterion: professional needs: – to gain a profession to gain employment, to strive for professional development;	CG	183	46.21	135	34.09	78	19.70	0.138
	EG	181	47.38	126	32.98	75	19.64	
The values-based and motivational criterion: professional motives: to gain a profession, to continue learning.	CG	207	52.27	119	30.05	70	17.68	0.395
	EG	206	53.93	107	28.01	69	18.06	
The innovative-and-cognitive criterion: general professional knowledge about the fundamentals of production, computer technologies, the fundamentals of entrepreneurship, labour safety, professional terminology;	CG	157	39.65	135	34.09	104	26.26	0.233
	EG	155	40.58	124	32.46	103	26.96	
The innovative-and-cognitive criterion: technological (professional) knowledge about material science, production process	CG	128	32.32	159	40.15	109	27.53	0.252
	EG	119	31.15	152	39.79	111	29.06	

technologies, scientific organization of the workplace, repair works.								
An average level of professional competency	CG	170	42.93	141	35.61	85	21.46	0.270
	EG	171	44.76	131	34.29	80	20.95	

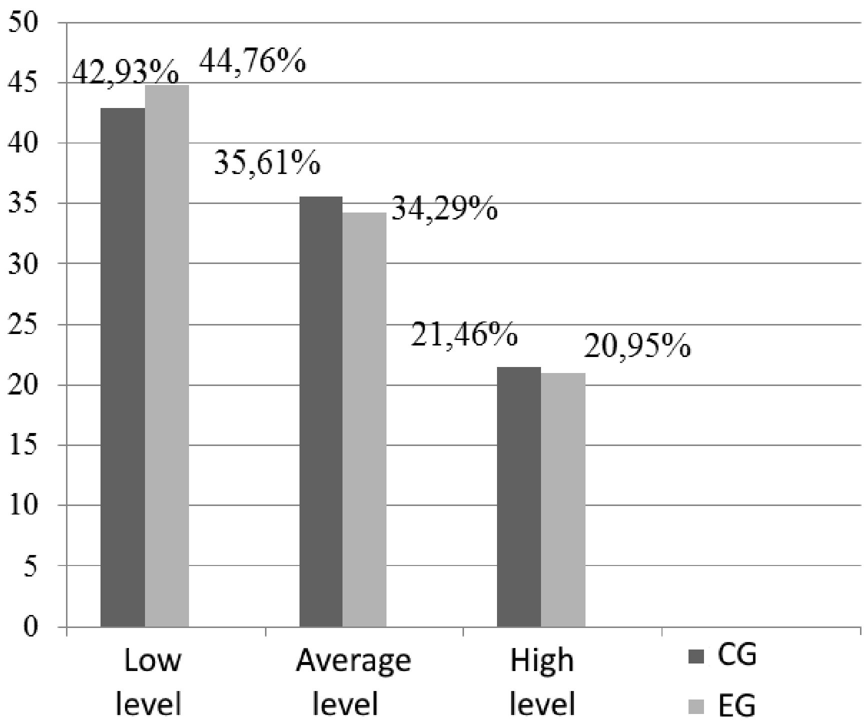

Fig. 2. The results obtained from identifying professional competency levels in future specialists (at the ascertaining stage of the experiment)

The number of CG students with a low (consumer-related) level is lower by 1.83% than that of EG students. The number of CG students with average (generative) and high (productive) levels is by 1.32% and 0.51 higher respectively.

Therefore, the data obtained at the ascertaining stage of the experiment has made it possible to reveal an insufficient level of professional competency.

The results obtained from identifying professional competency levels in future specialists at the formative stage of the experiment are shown in Table 5.

Thus, 31.94% of EG students turned out to be at a high (productive) level of professional competency; 35.08% of them – at an average (generative) level; 32.98% of them – at a low (consumer-related) level.

Compared to CG results: the number of students with a high (productive) level is higher by 9.22%; the number of students with an average (generative) level – higher by 1.49%; the number of students with a low (consumer-related) level – lower by 10.71%. The differences between CG and EG regarding the level of general knowledge are statistically significant (χ^2 = 11.974) and do not exceed the established limits and are at the level α = 0.05.

Table 5. The results obtained from identifying professional competency levels in future specialists (at the formative stage of the experiment)

Indicators	Groups	Levels						χ^2
		Low (consumer-related)		Average (generative)		High (productive)		
		Number of students	%	Number of students	%	Number of students	%	
The values-based and motivational criterion: professional interests – an interest in a particular profession and production	CG	218	55.05	93	23.48	85	21.47	14.275
	EG	159	41.62	111	29.06	112	29.32	

technologies								
The values-based and motivational criterion: professional needs: – to gain a profession to gain employment, to strive for professional development;	CG	178	44.95	136	34.34	82	20.71	14.266
	EG	126	32.98	141	36.91	115	30.11	
The values-based and motivational criterion: professional motives: to gain a profession, to continue learning.	CG	199	50.25	123	31.06	74	18.69	11.606
	EG	157	41.10	116	30.37	109	28.53	
The innovative-and-cognitive criterion: general professional knowledge about the fundamentals of production, computer technologies,	CG	151	38.13	139	35.10	106	26.77	10.270
	EG	109	28.53	137	35.86	136	35.61	

the fundamentals of entrepreneurship, labour safety, professional terminology;								
The innovative-and-cognitive criterion: technological (professional) knowledge about material science, production process technologies, scientific organization of the workplace, repair works.	CG	117	29.55	165	41.67	114	28.78	13.044
	EG	72	18.85	171	44.76	139	36.39	
An average level of professional competency	CG	173	43.69	133	33.59	90	22.72	11.974
	EG	126	32.98	134	35.08	122	31.94	

The results obtained during the ascertaining and formative stages of the experiment were compared (see Table 6) and effective positive changes in professional competency levels were determined to illustrate that the levels of CG and EG students' knowledge have increased statistically during the formative stage of the experiment.

Table 6. The results obtained from identifying professional competency levels in future specialists (at the ascertaining and formative stages of the experiment)

Levels	CG				EG			
	The ascertaining stage		The formative stage		The ascertaining stage		The formative stage	
	Number	%	Number	%	Number	%	Number	%
Low	170	42.93	173	43.69	171	44.76	126	32.98
Average	141	35.61	133	33.59	131	34.29	134	35.08
High	85	21.46	90	22.72	80	20.95	122	31.94
Total:	396	100	396	100	382	100	382	100

The results from analyzing data presented in Table 9 indicate effective positive changes in professional competency levels in CG and EG students by the innovative-and-cognitive criterion. These results are presented in Figures 3 and 4.

The analysis of the diagrams shows that a certain increase in the indicators of high (productive) and average (generative) levels and, accordingly, a certain decrease in the indicators of low (consumer-related) level are more characteristic of EG students. Indeed, the number of EG students who are at a high (productive) level of professional competency at the formative stage of the experiment is by 9.77% higher than that of CG students. As for average (generative) and low (consumer-related) levels, this number is by 1.49 % higher and by 10.71 % lower.

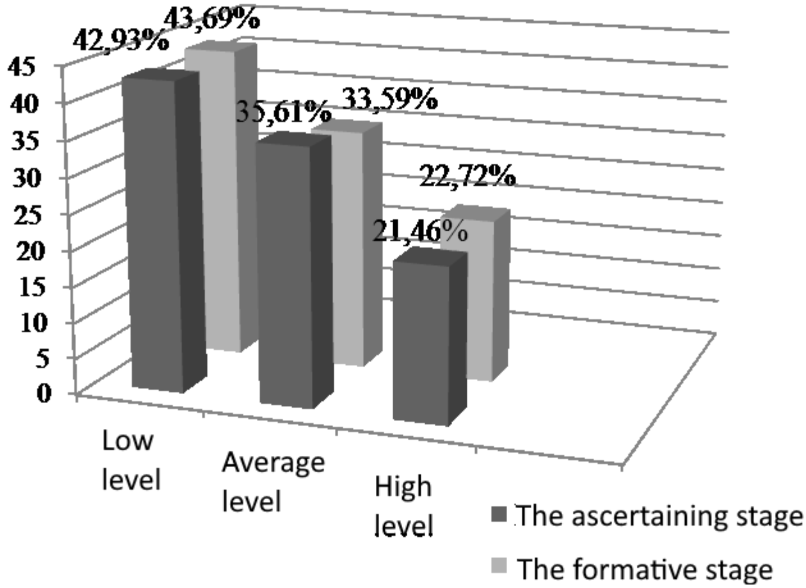

Fig. 3. The dynamics of professional competency levels in CG students

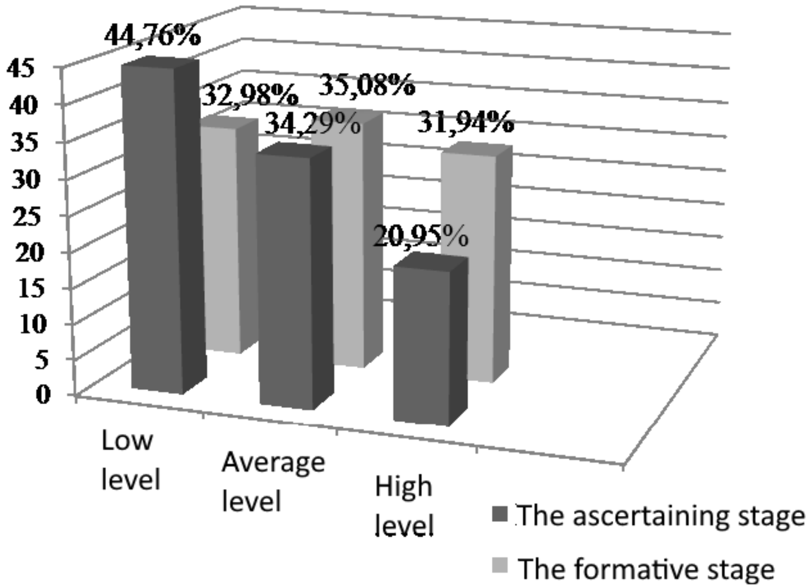

Fig. 4. The dynamics of professional competency levels in EG students

The empirical values of the χ^2 criterion for the results obtained from identifying professional competency levels in future specialists are shown in Table 7.

Table 7. Empirical values of the χ^2 criterion for the results obtained from identifying professional competency levels in future specialists

	CG (the ascertaining stage)	CG (the formative stage)	EG (the ascertaining stage)	EG (the formative stage)
CG (the ascertaining stage)	0	0.403	0.270	9.501
CG (the formative stage)	0.403	0	0.363	11.974
EG (the ascertaining stage)	0.270	0.363	0	15.585
EG (the formative stage)	9.501	11.974	15.585	0

The obtained values of the observed χ^2 criterion are compared with the critical value $\chi^2_{cr} = \chi^2_{0.05}(2) = 5.99$.

Below are the comparisons that demonstrate a significant difference.

Comparison: CG and EG at the formative stage – χ^2_{emp}=11.974; EG formative stage and ascertaining stages – χ^2_{emp}=15.585; CG at the ascertaining and EG at the formative stage – χ^2_{emp}=9.501.

Given that α = 0.05, one can indicate no significant difference when comparing. Comparison: CG and EG at the ascertaining stage – χ^2_{emp} = 0.270; CG at ascertaining and forming stages – χ^2_{emp} = 0.403; CG at the formative stage and EG at the ascertaining stage – χ^2_{emp} = 0.363.

The results obtained from test χ^2 prove that the formative stage of the experiment has resulted in really positive changes in the levels of future specialists' professional competency.

Thus, the research proves that the use of SMART complexes of academic disciplines as an integrative information environment in which students learn positively affects personal development of future specialists as a whole, their professional competency and ensures the effectiveness and flexibility of the educational process in PE schools. It provides students with wider opportunities to build their learning trajectory, which causes the need to develop and apply SMART complexes of academic disciplines in their professional training.

5. Conclusions and prospects for further research

Being aware of the concept of SMART complexes of academic disciplines, one can define pedagogical possibilities of realizing the requirements of an environmental approach for their development and application as an integrative information environment in professional training of future specialists.

When developing such complexes, it is essential to take into account the content of educational information, students' exceptional perception of its nature at each stage of their intellectual and psycho-physiological development and, most importantly, the features of an environmental approach, which are manifested in the structural construction of an integrative information environment, in the general scenario for developing SMART complexes of academic disciplines, in the selection of information and logical content of educational material based on an integrative information environment, in the determination of types of learning tasks with self-actualizing and creative environments, in the designing of ways for control and self-control of knowledge in a self-evaluative environment, in the creation of an interface and navigation using information and communication environment.

SMART complexes of academic disciplines imply an adaptive implementation of the educational process in PE schools by using SMART technologies. This requires certain changes in the educational paradigm, namely, the transition from a traditional model of learning to e-learning with the use of SMART complexes of academic disciplines in professional training of future specialists.

The introduction of SMART complexes of academic disciplines causes the need to connect the components of an integrative information environment with social, economic and technological environments of PE schools, which will enhance the quality of professional training of future specialists.

Further research should focus on psycho-pedagogical, organizational and technological conditions for introducing SMART complexes of academic disciplines in professional training of future specialists, as well as methodical principles of monitoring the quality of professional training of future specialists using SMART complexes of academic disciplines.

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