Adapting engineering education to challenges of sustainable development

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Adapting engineering education to challenges of sustainable development

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Abstract. Textile and clothing industries generate a lot of waste at both production stages and in the process of wearing garments. Every inhabitant of developed countries annually wastes up to 30 kg of used but still suitable clothes, which decompose very slowly in natural conditions. The broadest possible implementation of textile waste processing technologies, such as downcycling and upcycling, is the key to ensuring the successful operation of the textile and clothing industries under conditions of sustainable development. The paper goal is to determine factors controlling students' upcycling behaviour to strengthen the educational components and meet sustainable development challenges for the garment industry. Based on interpersonal and planned behaviour models, 93 students of 1-6 years majoring in clothing technology, design and sectoral professional education were surveyed to understand their upcycling behaviour. The surveyed students are divided into similar-sized groups of optimists (practice upcycling more than once every three months) and pessimists (less than once a year). Upcycling behaviour was shown to correlate with intentions, which are, in turn, affected by social factors, attitude, and perceived behaviour control. Perceived habits and facilitating conditions have a relatively small impact. There is almost no difference between students of different years of study and specialities. Students' understanding of the benefits of upcycling is shallow and does not change with training years. Amid a highly-positive attitude towards upcycling, a low level of knowledge of the benefits and lack of progress with years indicate existing problems in developing upcycling behaviour in the learning process.

1. Introduction

In today's world economic system, two competing sectors coexist. They are linear economy and circular economy [1,2]. Since the Industrial Revolution, the linear economy model has dominated for centuries as the only available business model using available technologies. This model aimed at increasing industrial production, employment, urban development, living standards, profits and demand for all goods. Its main stages were the extraction of resources by industry (usually in unlimited quantities), production and distribution. Consumers used the products for some time (during the product's life) and then disposed of as waste in landfills or incineration. This model has a one-dimensional linear dimension, where the input of raw materials (stocks of which fall over time), and the output - waste, the amount of which is growing.

The concept of circular economy assumes and is based on the idea of the ability of the economic system to recover, which allows implementing the concept of sustainable development. The circular economy converts end-of-life goods into resources for other goods [1]. This transformation closes the so-called loops in industrial ecosystems and minimises waste. The main

thing is that the economic logic in such a system has changed. Sufficiency replaces production. The new reasoning calls for the reuse of all that is possible, for recycling what cannot be reused, repairing what is broken, and restoring what cannot be repaired.

The implementation of the circular economy concept applies to virtually all areas of economic activity. Absolute priorities are energy-saving [3, 4] with the simultaneous development of renewable energy [5, 6]. The next set of challenges concerns the economic use of resources such as water [7, 8], forests and plants as a source of medicines and other substances [9, 10], the comprehensive implementation of green chemistry technologies [11, 12]. Last but not least, it is to solve the problems of utilisation and processing of waste from various industries and reduce industrial carbon emissions [13, 14]. A study of seven European countries showed that the transition to a circular economy would reduce greenhouse gas emissions in each country by 70% and increase its labour force by about 4%. The lowest possible carbon consumption will characterise the economies of these countries [1].

Strange as it may seem, the global fashion industry annually produces 4% of the world's waste [15]. Because clothing is a very symbolic product, often a sign of high social status, consumers want to buy clothing as often as possible [16]. In turn, the industry offers more and more inexpensive clothes and supports the variability of fashion trends. As a result, in developed countries, each consumer annually throws away up to 30 kg of used textiles [17]. Old clothes are more often thrown away not because they are worn out, but because they are outdated, and old clothes are getting faster and faster.

Modern materials from which clothes are made cannot decompose appropriately in the environment and eventually pollute the water. In addition, the textile and garment industries affect carbon emissions [18, 19]. Global greenhouse gas (GHG) emissions continue to rise due to high consumption. This fact becomes evident when comparing the dynamics of territorial emissions (i.e. industrial emissions in a given area) and consumer emissions. In the latter case, emissions from local production and goods and services imported into the area are considered. Consumer emissions are about twice as much as territorial emissions in industrialised countries. For example, the UK's territorial emissions between 1990 and 2009 showed a decrease of 27%, while GHG emissions based on UK consumption showed a 20% increase. Thus, the rapid increase in consumption, in this case, nullifies efforts to reduce carbon emissions from local industry.

As already mentioned, waste from the textile industry has a significant impact on waste generation. Therefore, changing consumer behaviour can significantly reduce waste and emissions across national borders. In turn, the textile industry has considerable potential for reducing waste and emissions in the case of transition to the principles of sustainable development and implementation of the circular economy model [18, 19]. Circular models and relevant practices help reduce the environmental impact of textile production, use and disposal. The resulting products are characterised by a high potential for energy and non-renewable resources savings. Eco-fashion textiles meet ecological and quality criteria suitable for processing and biological decomposition of the material. Thus, it reduces the volume of chemicals released into the ecosystem.

People of all ages and qualifications are central to circular economy models. Insufficient knowledge or fear of the unknown significantly slows down the spread of circular economics [1]. Therefore, it is necessary to promote the formation of new traits in human behaviour, such as, for example, the purchase of environmentally friendly products, processing, use less plastic packaging, energy-saving [18, 19]. Waste disposal can significantly reduce waste, energy consumption, and greenhouse gas emissions.

Widespread circular economy ideas are impossible without incorporating them into academic and professional communities. The intellectual forces of nations are scholars' knowledge, and expertise concentrated in universities [20]. In addition, the worldview of future generations is formed in universities. Therefore, to achieve the goals of sustainable development, it is necessary

to bring the content of educational programs to the requirements of professional activity in the conditions of sustainable development [21–23].

Technologies studied in training a future engineer usually relate to specific stages of the product's so-called "life cycle". This technological "life cycle" starts with the stage of product design and engineering. This stage becomes crucial to ensure the sustainability of production. At this stage, the possibility of recycling the product after its use by the consumer is established.

Other technological stages that should be noted are cutting, product manufacturing, transferring the developed technology to production, product sales and stage of its use. The need for time is to design the possibility of reusing the product or adapting the product to another purpose, i.e. different ways of recycling. However, this stage is still often disregarded in the study of technology.

The need or order for specialists familiar with modern recycling technologies comes from employers. There is already a contradiction between the needs of employers and the existing competencies of graduates. It encourages changing the content of engineering training for future professionals.

In production, the transition is made from optimising individual stages of technology to the full understanding and optimisation of the technological chain throughout the product's life cycle. Accordingly, specialists who understand this and can work at all stages of the life cycle and predict the consequences of technological activities are in need. Today, there is a lack of such specialists, as no targeted training would take into account modern requirements. There are no specialists - there is no production, so modern technologies cannot be implemented.

Students who study in the training programs of engineering and pedagogical specialists in the clothing industry and specialise in textile technology or textile design must master the following competencies:

a) know the methods of effective organisation of work in compliance with environmental safety requirements;

b) be able to design and manufacture modern clothing for various purposes;

c) be able to organise the educational process in the relevant disciplines in sectoral educational institutions,

d) know the methods of optimising materials and reducing industrial waste.

All these knowledge and skills are formulated following the requirements of the linear economy. There is a lack of skills needed to succeed in the circular economy. In particular, there are no requirements for processing textile waste and producing textile products using secondary raw materials. Today, the critical competencies for working in the context of sustainable development of the textile and clothing industry have not yet been formulated.

A whole layer of knowledge about existing and promising approaches and technologies aimed at the optimal use of waste is ignored at all stages of production, utilisation and waste disposal. First of all, recycling and upcycling technologies should be mentioned. At the same time, there is a steady demand from employers for professionals with these technologies [24,25]. The article aims to study the existing problems that hinder the formation of the necessary competencies of future technologists and designers of the clothing industry. Formulating ways to overcome these problems will contribute to the acquisition of knowledge and skills in the disposal of waste from the fashion industry and work in the business environment of the circular economy model.

2. Experimental
2.1. Survey methodology
A survey of students of the Faculties of Fashion Industry and Design of the Kyiv National University of Technology and Design (KNUTD) was conducted to determine personal motives and various aspects of attitudes towards processing wastes and raw materials. A total of 93 students in years 1-6 of bachelor's and master's degrees took part in the study.
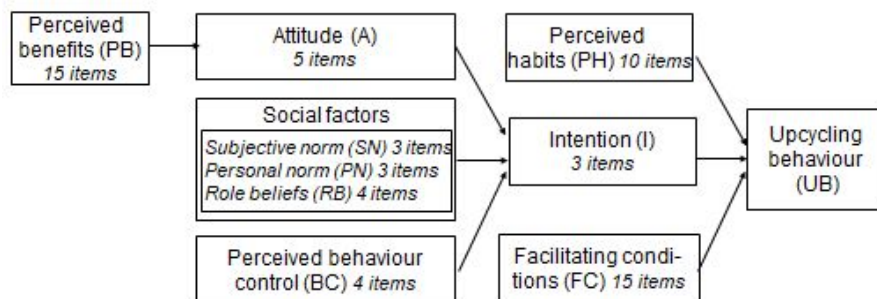
Figure 1. Combined model [28–30] of the Theory of Interpersonal Behaviour and the Theory of Planned Behaviour.

The materials used in the survey were developed according to the principles of the Theory of Interpersonal Behavior [26] and the Theory of Planned Behavior [27]. The combined model, which contains elements of both of the above, was developed in [28–30]. The combined model was used to study the behaviour of people in the UK who are actively involved in upcycling. According to [26, 27], several primary factors have been identified that should shape a person's attitude to waste recycling. These factors are indicated in the block diagram in figure 1.

The influence of each factor is estimated based on the answer to the different number of questions. The numbers of items are illustrated in figure 1. The questionnaire contained 62 questions on nine individual influencing factors in the scheme. A separate question was asked about personal experience in the scheme's upcycling frequency shown as upcycling behaviour (UB). The content of individual questions, if necessary, will be shown later in the text. The principles of the combined model and questionnaire used are described in more detail in [31, 32].

Eight of the nine factors have a direct impact either directly on the frequency of upcycling behaviour or intentions regarding upcycling (figure 1). Only the perceived benefits (PB) factor directly influences the attitude to upcycle (factor A) and does not directly influence upcycling behaviour (UB). However, this factor is shown in the scheme. Understanding the benefits helps to improve the argumentation of upcycling practices and can seriously affect attitudes toward upcycling.

A 7-point Likert scale [33] was used to quantify the responses to the seven factors in figure 1. A 7-point Likert scale ranges from one extreme to another, like "extremely likely" to "not at all likely." For six factors, the ranking included the following options: strongly disagree (1 point), disagree (2 points), somewhat disagree (3 points), either agree or disagree, i.e. not determined (4 points), slightly agree (5 points), agree (6 points), and strongly agree (7 points). For each of the five questions for the seventh factor (Attitude), the range from strongly disagree (1 point) to strongly agree (7 points) was substituted by other options, for example, unpleasant (1 point) - pleasant (7 points). As you can see, the scale remained unchanged.

The 7-point scale is the most accurate scale among other Likert scales; it is easy to use and better reflects the respondent's precise assessment. At the same time, as a shortcoming, it is known that previous questions may influence respondents' answers. According to the model in figure 1, certain factors influence respondents' upcycling behaviour (UB), which is assessed by the frequency of application of upcycling techniques. Respondents chose one of eight available answers that best describes their experience: never use upcycling (1 point), less than once a year (2 points), once a year (3 points), once every six months (4 points), once a quarter (5 points), once a month (6 points), once a month week (7 points), and more than once a week (8 points).

2.2. Statistical treatment
Statistical analysis of the results was performed using the statistical software package IBM SPSS version 21. Descriptive statistics were applied for the results' general descriptions, which calculate the mean and median values, standard deviations and standard errors (SE). The

significance threshold in all tests was $p < 0.05$.

Correlation analysis methods analysed the presence or absence of correlations between individual factors. As virtually all indicators are rank variables, Spearman's rank correlation coefficients were calculated in the correlation analysis.

Table 1. Cronbach's Alpha to test the reliability of a scale.

Factors	Number of items	Cronbach's Alpha
Perceived benefits (PB)	15	0.957
Attitude (A)	5	0.922
Subjective norm (SN)	3	0.643
Personal norm (PN)	3	0.814
Role beliefs (RB)	4	0.837
Social factors (all together)	10	0.863
Perceived behaviour control (BC)	4	0.891
Intention (I)	3	0.928
Perceived facilitating conditions (FC)	15	0.904
Perceived habits (PH)	10	0.813

As a preliminary step, the consistency of the survey questions and, accordingly, the reliability of the survey results were investigated. The Cronbach's Alpha test was used for this purpose. Cronbach's alpha measures internal consistency between elements in a group. The consistency between separate questions concerning the same factor is investigated in our case. Cronbach's alpha is a coefficient of reliability (or consistency) that indicates how closely a set of elements is linked as a group. The results are shown in table 1. For the factor of subjective norms (SN), Cronbach's Alpha value is close to 0.64. For all other factors, Cronbach's Alpha exceeds the value of 0.8. Acceptable internal consistency is suggested for the scale if Cronbach's Alpha varies between 0.6 and 0.79. A Cronbach's Alpha value above 0.8 indicates good reliability.

Fitting experimental distribution curves using nonlinear curves with the fitting parameters, function expression, constraints and determination coefficients R^2 was performed using the software package OriginLab, version 8.

3. Results

3.1. Descriptive statistics
Figure 2 gives the general impression of the obtained results. It illustrates the average scores for each factor. They are obtained by summing all the answers to all the questions and calculating the arithmetic mean. Abbreviated factor names were first described in figure 1. The 4-point ring in figure 2 corresponds to the boundary between negative and positive answers. The shaded area contains negative answers, i.e. those cases when the respondents' answers are dominated by disagreement (average score in the range from 1 to 4 points) with the given statement. The unshaded area with an interval of 4 to 7 points corresponds to positive answers.

As we can see, only three factors, namely A, I and BC, confidently confirm the positive attitude of the respondents. In the case of factor A, the average score of the respondents roughly corresponds to the answer "agree" or 6.05 ± 0.26 points. For the I factor, the average score is close to "somewhat agree" or 4.89 ± 0.35 points. For the BC factor, the average answer is intermediate, namely 5.59 ± 0.30 points.

For the other five factors, namely SN, PN, RB, PH, FC, the average scores are slightly above zero (4 points) and range from 4.17 to 4.54. According to the respondents, the influence of these factors does not reach even the weakest positive assessment of "somewhat agree". For another
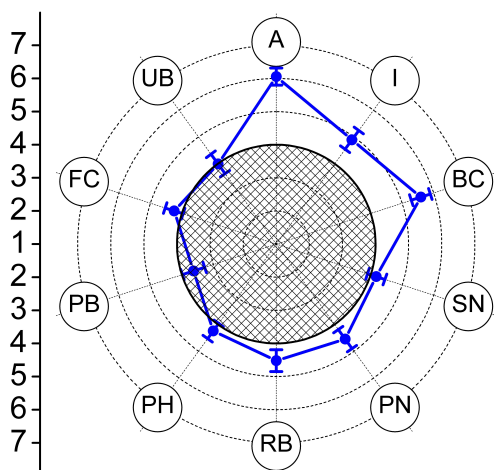
Figure 2. Average values of all factors in points. The shaded area, limited by a 4-points circle, separates disagreement (shaded) and agreement (unmarked) areas in answers.

factor, RV, the average response of the respondents was between uncertainty (4 points) and weak disagreement with the proposed statements. The average score for PB is 3.63 ± 0.35.

For UB, the average value was 3.99 ± 0.36. However, unlike other factors, a score of 4 does not mean a zero mark but corresponds to the frequency of upcycling once every six months. The obtained average value does not allow to draw any conclusions about the most common practice of upcycling. It does not contain information on the distribution of the number of respondents according to the frequency of upcycling. Accordingly, the average frequency can reflect the actual situation and be a superposition of indicators of several respondents who have entirely different attitudes to the frequency of upcycling. This issue will be discussed in detail in the following sections.

3.2. Correlations between influencing factors

As mentioned above, Spearman's Rank Order Correlation was calculated to study correlations between rank values. According to the scheme, the influence of various factors on upcycling behaviour (UB) is ultimately reduced to the impact of factors I, PH and FC (figure 1). Thus, it is necessary to investigate first the existing correlations between, on the one hand, the listed factors and, on the other hand, UB. The calculation results are given in table 2.

The highest level of correlation exists between all items of the I factor and HC. The correlation shows a very high significance level ($p < 0.01$) and can be attributed to the average strength of correlations when the coefficients vary r_S between 0.387 and 0.454.

The opposite picture is observed in the case of facilitating conditions (FC) when significant correlations are completely absent. In other words, the presence or absence of FC does not affect the upcycling behaviour of respondents.

The correlations between perceived habits (PH) and UB is not evident. On the one hand, no correlation is observed between the averages of PH and UB. On the other hand, there is a correlation between 9 out of 10 individual items of PH and UB. The strength of such correlations is relatively weak. The value of significant r_S ranges between 0.212 and 0.361. The significance level in different cases corresponds to the probabilities of 95% and 99%. The most probable reason for the lack of correlation between average PH and UB is the unrepresentative nature of UB values. As already mentioned, the nature of UB distribution by the number of respondents is far from normal. Accordingly, the average value poorly characterises the available sample. However, correlations between individual indicators will need to be considered in analysing the results obtained.

According to the above, the most critical factor is the factor of intentions. The I factor, in turn, is formed under the influence of factors A and BC and three social factors (figure 1). The

Table 2. Spearman's Rank Order Correlations between items of intension (I), perceived habits (PH), facilitating conditions (FC) against upcycling behaviour (UB).

| Correlation between factors	I - UB	PH - UB	FC - UB
Number of significant correlations r_S among available item pairs	3 out of 3	9 out of 10	0 out of 15
The values of r_S between average factors' ranks	0.447**	-0.044	-0.071
Range of significant individual r_S	$0.387** - 0.454**$	$0.212* - 0.361**$	-
Range of all individual r_S	$0.387** - 0.454**$	$0.169 - 0.361**$	$-0.158 - 0.17$
The items with max r_S	I1	PH7	-

** Correlation is significant at the 0.01 level (2-sided)
* Correlation is significant at the 0.05 level (2-sided)

results of calculations of correlation coefficients between individual and average values are given in table 3.

According to the results, significant correlations are present in all five pairs of factors. Moreover, the significance level of correlations between the average values in all cases exceeds 99%. The strength of the correlation consistently exceeds the value of $r_S > 0.4$. The average correlation coefficient for I and BC reaches 0.661. Thus, the factor of intention formation depends on all five factors, as shown in figure 1. At first glance, this dependence is slightly higher for factors A and BC and somewhat lower for social factors. However, a more detailed analysis is needed to clarify the role of individual factors, including individual component effects.

3.3. Bi-modal distribution for upcycling behaviour
Surveys indicate the presence of two modes in the behaviour of respondents regarding the frequency of use of upcycling and recycling techniques (figure 3).
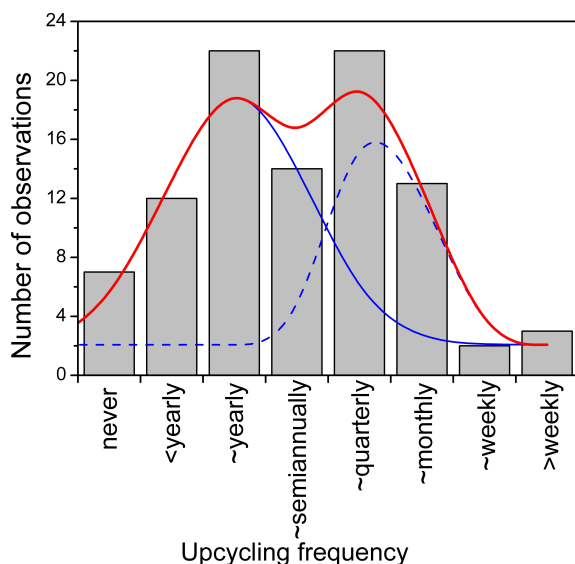
Figure 3. The number of observations as a function of the frequency of upcycling.

These modes divided the respondents almost in half. This distribution is a reasonably stable value that does not depend on external parameters, such as speciality, year of study, gender, etc. Accordingly, it is possible to assume that students at the beginning of their studies have permanent advantages (positive or negative attitude) over the practical application of recycling.

Table 3. Spearman's Rank Order Correlations of the individual (I1-I3) and average (I) values of intension vs both individual and average ranks of attitude (A), perceived behaviour control (BC), subjective norm (SN), personal norm (PN) and role beliefs (RB).

| Pair of factors	A(1-5) - I1	A(1-5) - I2	A(1-5) - I3	A(1-5) - I
Number of significant correlation pairs	5 out of 5	5 out of 5	5 out of 5	5 out of 5
Correlations r_S between average values	0.538**	0.506**	0.488**	0.549**
Range of significant r_S (the items with max r_S)	0.363**-0.549**(A5)	0.352**-0.559**(A5)	0.280**-0.491**(A5)	0.357**-0.567**(A5)
Pair of factors	BC(1-4) - I1	BC(1-4) - I2	BC(1-4) - I3	BC(1-4) - I
Number of significant correlation pairs	4 out of 4	4 out of 4	4 out of 4	4 out of 4
Correlations r_S between average values	0.666**	0.520**	0.584**	0.661**
Range of significant r_S (the items with max r_S)	0.289**-0.665**(BC3)	0.284**-0.580**(BC1)	0.254*-0.558**(BC3)	0.272**-0.634**(BC3)
Pair of factors	SN(1-3) - I1	SN(1-3) - I2	SN(1-3) - I3	SN(1-3) - I
Number of significant correlation pairs	3 out of 3	3 out of 3	3 out of 3	3 out of 3
Correlations r_S between average values	0.601**	0.559**	0.500**	0.591**
Range of significant r_S (the items with max r_S)	0.338**-0.520**(SN2)	0.411**-0.466**(SN1)	0.275**-0.482**(SN1)	0.361**-0.522**(SN1)
Pair of factors	PN(1-3) - I1	PN(1-3) - I2	PN(1-3) - I3	PN(1-3) - I
Number of significant correlation pairs	3 out of 3	3 out of 3	3 out of 3	3 out of 3
Correlations r_S between average values	0.484**	0.441**	0.406**	0.472**
Range of significant r_S (the items with max r_S)	0.265*-0.529**(PN3)	0.251*-0.495**(PN2)	0.233*-0.445**(PN3)	0.262*-0.501**(PN3)
Pair of factors	PB(1-4) - I1	PB(1-4) - I2	PB(1-4) - I3	PB(1-4) - I
Number of significant correlation pairs	4 out of 4	4 out of 4	4 out of 4	4 out of 4
Correlations r_S between average values	0.550**	0.591**	0.559**	0.600**
Range of significant r_S (the items with max r_S)	0.314**-0.521**(RB2)	0.396**-0.567**(RB2)	0.338**-0.526**(RB4)	0.363**-0.551**(RB2)

** Correlation is significant at the 0.01 level (2-sided)
* Correlation is significant at the 0.05 level (2-sided)

These advantages do not change during the learning process. As shown in figure 3, about half of the students resort to upcycling once a year or less, i.e. they do not actually have such a permanent habit. The other half does it once a quarter or more often. In this case, one can talk about the practice of applying upcycling. The approximate curve in figure 3 can be written as follows:

$$y = 1.58245 + \frac{39.91154}{2.01461\sqrt{\frac{\pi}{2}}}exp^{\left(-\frac{(x-3.14011)^2}{2.01461^2}\right)} + \frac{32.6833}{0.57042\sqrt{\frac{\pi}{2}}}exp^{\left(-\frac{(x-5.970266)^2}{0.57042^2}\right)} \qquad (1)$$

At the same time, the nature of the identified bimodality is not entirely clear. Figure 4 illustrates the observation numbers as a function of the scored points. For most factors, there are no signs of bimodal behaviour. Some symptoms of such behaviour can be attributed to factors of role beliefs (RF), perceived benefits (PB), and partially facilitating conditions (FC). In some cases, the distributions tend to gradually increase from left to right, indicating that a favourable opinion to the factor impact prevails over the negative one. Other curves demonstrate close to the normal curves.
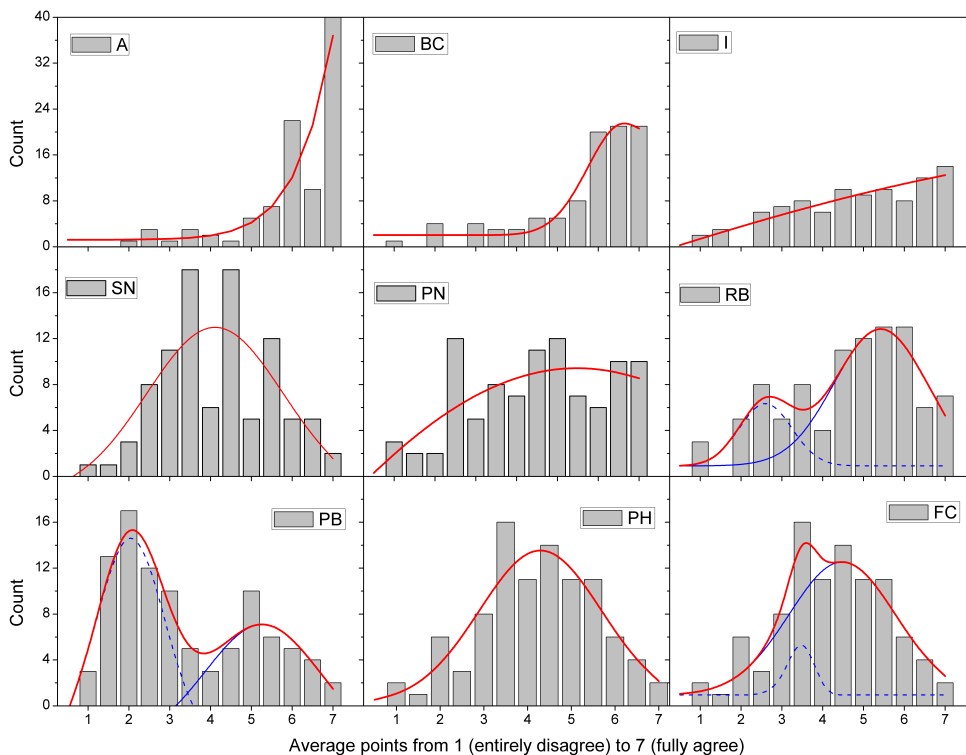
Figure 4. The number of counted observations as a function of the average number of points in responses related to attitude (A), behaviour control (BC), intention (I), subjective norm (SN), personal norm (PN), role beliefs (RF), perceived benefits (PB), perceived habits (PH) and facilitating conditions (FC).

However, the main practical conclusion is that the data obtained still do not provide sufficient grounds to identify the most influential factors that shape the respondents' behaviour concerning recycling techniques. Under such conditions, it seems logical to build additional simplified models that will be able to identify the most influential items and explain at least part of the sample.

4. Discussion

According to the results, future specialists are poorly versed in recycling technologies. They do not understand their importance and are not even interested. There are no significant changes over the years of study, which is an obvious disadvantage of the learning process used. Accordingly, the conditions for sustainable development of the industry will not be provided by relevant specialists in the coming years.

4.1. Accessing strengths of influencing factors

The results obtained during the study indicate a positive students' attitude towards upcycling practices. However, this positive attitude does not seem conscious and, perhaps, reflects general fashion trends rather than a mindful attitude. The lack of correlations with PBs and evident scepticism about possible benefits from upcycling activities are noteworthy. Then, it is not easy to expect that future teachers and engineers in the clothing industry who are not aware of the benefits of recycling (figure 2) will consciously use environmental standards in their professional work.

The results' analysis allows one to transform the primary scheme in figure 1, as the correlations between individual behavioural factors were not significant in some cases. On the contrary, statistically significant correlations were found for other factors. The updated diagram is shown in figure 5. The double arrow in the diagram illustrates correlations of the highest degree - at the level of 99% or $p < 0,01$. Single arrow - slightly weaker, but significant correlation (95% or $p < 0.05$). The dotted line in the arrow indicates no significant correlation.
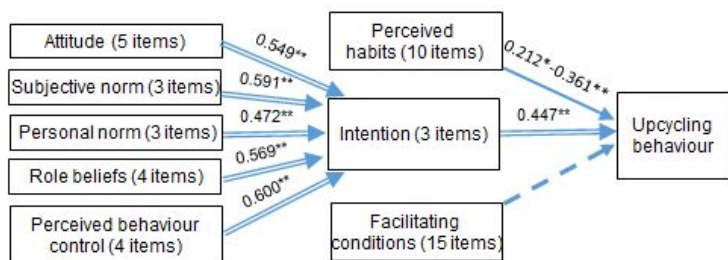
Figure 5. Combined model to explain upcycling behaviour with the values of average Spearman's Rank Order Correlations between factors.

As can be seen from figure 5, the formed intentions of students correlate well with upcycling behaviour. In contrast, available facilitating conditions (FC) to a greater extent and perceived habits (PH) to a lesser extent are not formative factors of upcycling. In turn, intentions are formed under the influence of all three factors shown on the scheme (A, BC and three social norms). Accordingly, the obtained data indicate a rather complex relationship between formative factors and upcycling behaviour. It is impossible to identify the most critical elements at this stage. To answer this question, one needs to make certain assumptions and develop on this basis further models, which will be implemented in the next section.

4.2. Regression model explaining upcycling behaviour

Upcycling behaviour is a complex function of many factors. These factors were grouped into nine groups, which combined the answers to 62 questions. The correlation of UB with FC and PB factors is minimal, while these correlations are significant for the other seven groups. However, due to the mentioned complex dependence on individual items, it is impossible to say which questions and answers give the most robust understanding of the respondents' upcycling behaviour.

Models and corresponding logistic regressions will be built to identify these critical items. The apparent disadvantage of logistics models is that they, due to simplicity, explain the behaviour of only part of the sample. On the other hand, the construction of logistics models can dramatically

reduce the number of influencing factors. It can be achieved by involving a limited number of the most influential items in logistic regressions. Questions with the highest correlation coefficients are used as determinants in correlation analysis. Two questions with the highest correlations for factors A, SN, PN, RB and BC, three questions for factors I and PH were selected. FC and PB are not included in the analysis because of the absence of significant correlations with UB. All answers on a 7-point scale were recoded into binary nominal data for logistic regression. Points in the responses from 1 to 4 were converted into 0 points corresponding to a negative attitude to upcycling. Former 5 to 7 points converted to 1 point (positive attitude).

The parameters of intentions (I) and upcycling behaviour (UB) are accepted as indicators that illustrate the ability of respondents to use upcycling technologies. UB indicators were also translated into a binary system, where 0 (negative upcycling behaviour) was used instead of 1-4 points obtained in the answers, and 1 - instead of 5-8 points.

According to the significant correlations between individual factors found in the previous sections, logistic regressions were constructed for three different models (figure 6). Independent variables were introduced as a single block (enter method) in all three models.
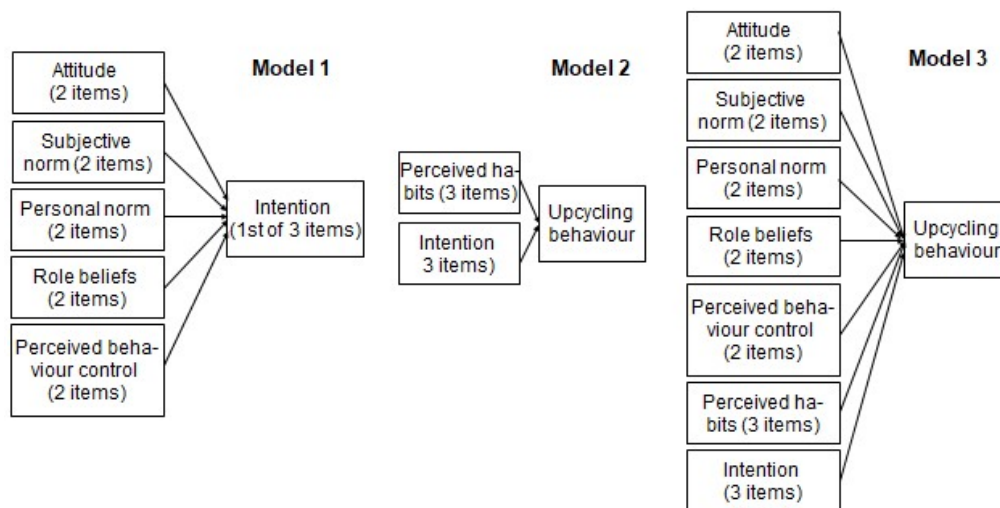
Figure 6. Three models to develop logistic regressions.

In the first model (table 4), factor I (more precisely I1) is a dependent variable and factors A, SN, PN, RB, and BC are influencing factors. This model explained the intentions' behaviour and contained ten items with the highest correlation coefficients among the five factors mentioned above as independent variables. The model was statistically significant (χ^2=65.085, df=10, $p < 0.000$). Therefore, the model can distinguish between respondents who intend and do not resort to upcycling. The model explained the variance of intentions from 49.6% (R^2 Cox & Snell) to 66.4% (R^2 Nagelkerke) and correctly classified 84.2% of cases.

One item to the factor BC (Upcycling things would be easy for me) has the largest contribution to the model with statistical significance p=0.005. The ratio of chances is 9.146. Therefore, respondents who said 'Upcycling things would be easy for me' intend to apply upcycling nine and half times more often than those who disagree with this statement. Another influential item (factor RB) is 'Upcycling fits my role in my family' (Exp(B)=5.317, p=0.024).

The second model focuses on the UB study (table 5). Three items of factors I and PH served are determinants. The model is statistically significant (χ^2=17.671, df=6, $p < 0.007$). It differentiates the respondents with frequent and rare upcycling practices. The model explained from 17.1% (R^2 Cox & Snell) to 23% (R^2 Nagelkerke) variances and correctly classified 67% of the variances.

Table 4. Logistic regression explaining likelihood of reporting relatively more probable upcycling intention by model 1.

Predictor	B	SE B	Wald's χ^2	df	p	Exp(B)
S11bin	0.937	1.263	0.551	1	0.458	2.553
S12bin	0.890	1.150	0.598	1	0.439	2.435
S22bin	1.370	0.994	1.900	1	0.168	3.937
S23bin	-0.202	0.937	0.046	1	0.829	0.817
S31bin	0.974	0.718	1.842	1	0.175	2.650
Upcycling fits my role in my family	1.671	0.738	5.125	1	0.024	5.317
A1bin	0.469	1.129	0.172	1	0.678	1.598
A5bin	-0.068	1.266	0.003	1	0.957	0.934
C1bin	1.036	0.978	1.122	1	0.289	2.817
Upcycling would be easy for me	2.213	0.780	8.043	1	0.005	9.146
Constant	-4.706	1.327	12.585	1	0.000	0.009

Tests		χ^2	df	p	
Omnibus tests of model coefficients		65.085	10	0.000	
Hosmer and Lemeshow test		7.618	7	0.368	

Model summary & classification					
Pseudo R^2 statistics		Cox&Snell	Nagelkerke		
		0.496	0.664		

| Overall percentage correct | | 84.2% | | | |

The third item belonging to factor I (I intend to upcycle things) produces the most significant impact. People who responded positively to this item were 4.466 times more likely to apply upcycling often (p=0.042). Model 2 is inferior to models 1 and 3 in predictive power, explaining only 67% of the sample.

The third model studies factors' effect on UB (table 6). Influencing factors were independent variables A (2 items), SN (2 items), PN (2 items), RB (2 items), BC (2 items), PH (3 items) and I (3 items).

The model is statistically significant (χ^2=27.371, df=16, $p < 0.038$). As model 2, model 3 differentiates respondents with rare and regular upcycling practices. The model explained from 25.3% (R^2 Cox & Snell) to 33.9% (R^2 Nagelkerke) variances and correctly classified 76.6% of variances. The most influential items (Upcycling things would be easy for me, and I intend to upcycle things) belong to factors BC and I, respectively. People who responded positively to the above items, in 4.361 (p=0.041) and 3.503 (p=0.122) times more often apply upcycling frequently.

The obtained results indicate the presence of certain shortcomings in the training of students, which can be reduced to the following.

First, students need to be taught to overcome the indifference threshold in their attitude to waste management in general and textile waste in particular. That graduates get used to, wanted and were able to coordinate their daily activities with the requirements of sustainable development of society.

Second, they must understand what benefits of sustainable development in society exist and what personal benefits they will have - ethical, social, economic, etc.

Third, it is clear that if students do not have upcycling skills, they do not want to do them. It is necessary to teach techniques that allow one to work in production without waste and provide

Table 5. Logistic regression explaining likelihood of reporting relatively more frequent upcycling by model 2.

Predictor	B	SE B	Wald's χ^2	df	p	Exp(B)
I1bin	0.433	0.803	0.291	1	0.590	1.542
I2bin	-0.081	0.888	0.008	1	0.927	0.922
I intend to upcycle things	1.497	0.735	4.141	1	0.042	4.466
H2bin	-0.421	0.550	0.585	1	0.444	0.656
H7bin	0.895	0.612	2.135	1	0.144	2.446
H8bin	-0.838	0.572	2.148	1	0.143	0.433
Constant	-1.508	0.494	9.302	1	0.002	0.221
Tests		χ^2	df	p		
Omnibus tests of model coefficients		17.671	6	0.007		
Hosmer and Lemeshow test		1.842	7	0.968		
Model summary & classification						
Pseudo R^2 statistics		Cox&Snell	Nagelkerke			
		0.171	0.230			
Overall percentage correct		67.0%				

knowledge on the organisation of the circular output.

The formation of key competencies of sustainable development for future specialists is not provided for in the recently approved educational standards of Ukraine. Meanwhile, demand from employers exists for specialists with waste management technologies at all stages of production, use and disposal of used products [34,35]. In today's conditions, the necessary skills and abilities are formed in students in fragments, during the study of individual disciplines, or in the process of their professional activities.

With the purposeful filling of education with ecological content and organisation of students' activities, which will promote the development of the features of a specialist in sustainable development, changes in the mentality of students can occur relatively quickly. At the same time, a fragmentary change in the content of academic disciplines is not enough. Mastering individual, unrelated modules do not provide an opportunity to look globally at a range of sustainable development issues. Therefore, achieving the desired effect requires significant changes in educational programs by introducing holistic disciplines. Such disciplines should be interdisciplinary in nature, which will allow not occasionally, but constantly to develop skills and knowledge of future specialists in sustainable development [36–38]. It is also evident that certain adjustments in their teaching should accompany the introduction of new disciplines. Student personalities and preferred learning styles [39, 40] should be taken into account, and pedagogical approaches that best meet the task of forming key competencies of sustainable development should be applied.

5. Conclusions

Sustainable development of the clothing industry involves introducing appropriate technologies. They will ensure consistent and optimal industrial waste administration at all stages of the product life cycle, from their design to the recycling of used items. Created technologies must be provided with qualified personnel who understand the importance of recycling technologies and have the necessary professional competencies.

The vast majority of students declare a positive attitude towards recycling or upcycling

Table 6. Logistic regression explaining likelihood of reporting relatively more frequent upcycling by model 3.

Predictor	B	SE B	Wald's χ^2	df	p	Exp(B)
S11bin	-0.911	0.870	1.097	1	0.295	0.402
S12bin	0.716	0.828	0.748	1	0.387	2.046
S22bin	-0.721	0.809	0.794	1	0.373	0.486
S23bin	0.676	0.802	0.710	1	0.399	1.967
S31bin	0.816	0.734	1.236	1	0.266	2.261
S32bin	-0.539	0.734	0.539	1	0.463	0.583
A1bin	1.098	0.890	1.522	1	0.217	2.997
A5bin	-0.853	1.108	0.592	1	0.441	0.426
C1bin	-1.472	0.906	2.640	1	0.104	0.230
Upcycling would be easy for me	1.473	0.721	4.167	1	0.041	4.361
I1bin	0.031	0.960	0.001	1	0.974	1.031
I2bin	0.849	1.093	0.604	1	0.437	2.337
I intend to upcycle things	1.254	0.810	2.397	1	0.122	3.503
H2bin	-0.807	0.627	1.656	1	0.198	0.446
H7bin	0.732	0.710	1.062	1	0.303	2.079
H8bin	-0.366	0.656	0.311	1	0.577	0.694
Constant	-1.706	0.754	5.119	1	0.024	0.182
Tests		χ^2	df	p		
Omnibus tests of model coefficients		27.371	16	0.038		
Hosmer and Lemeshow test		12.616	8	0.126		
Model summary & classification						
Pseudo R^2 statistics		Cox&Snell 0.253	Nagelkerke 0.339			
Overall percentage correct		76.6%				

technologies. However, this attitude is more theoretical and is often not supported by appropriate actions. The study showed that almost all students do not understand the benefits that can be provided by careful waste management - neither economic nor environmental nor the benefits at the level of consciousness.

In general, attitudes towards waste disposal or use upcycling practices remain almost unchanged throughout the years of study. In this regard, the ratio of undergraduate students does not differ from that of undergraduates. Therefore, training in existing curricula does not increase interest in the problem of waste recycling.

The distribution of students according to the frequency of application of upcycling techniques is bimodal. All respondents are roughly divided into those who practice them regularly (1-3 months or more) and those who use them sporadically (once a year or less).

Analysis of factors influencing the attitude of individuals to upcycling showed that the most influential is the factor of intentions, which, in turn, is formed under the influence of attitude factors, three social factors, and perceived behaviour control. A rather complex relationship exists between influential factors and upcycling behaviour.

The construction of logistic regressions allows identifying the most critical questions in the questionnaire. The answers to them allow predicting the intentions of upcycling and the frequency of upcycling for 70-80% of the sample. Only three items were among the most

influential: Upcycling things would be easy for me; I intend to upcycle things, and Upcycling fits my role in my family.

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