PHYSICS

Overall grade boundaries

Grade:	E	D	C	B	A
Mark range:	0 - 7	8 - 15	16 - 22	23 - 28	29 - 36

The range and suitability of the work submitted

There was clear evidence that a majority of students received relevant information from their supervisor as well as more good advice. The enthusiasm and dedication of the majority of students was evident. Many supervisors used observations (always appreciated) from the *viva voce* to illustrate their comments on the cover sheet. From these comments, there was also evidence that a majority of supervisors took their role seriously and had the success of their students at heart.

In general, the topics were well chosen, even for those candidates who did not manage to fully develop, throughout the essay, what they had initially planned. A wide range of essays varied in standard from excellent to very poor. Some students presented experimental work more suited to an internal assessment investigation easily carried out in a single laboratory session. The choice of some topics or RQ was unwise making it difficult to achieve initial goals. Highly unsuitable topics were rare and often predictable. In some cases, it seemed that students chose not to follow advice or were not provided with key information. Some students clearly waited too long before starting seriously hence could not cross the finish line on time. In some cases, physics theory was neglected; data were not effectively used and/or analyzed.

A wide range of topics covered different areas of physics for examples: *Particle size and flow rate; Temperature and Doppler Effect; Soap bubble longevity; Effect of velocity on meteor crater; Light dispersion in salt; Ferro-fluids in magnetic field; Fading of Cassiopeia A at 1420 MHz; Soccer ball size effects; Sound pitch in bowls; Guitar sound holes & Helmholtz; Temperature effects on a diode; Friction between the intertwined pages of two phone books; Frequency and flute length; Efficiency of spinning beyblade top launcher; Effect of aging ring density on thermal diffusivity of wood; Thermal convection cells; Greatest force in a tennis serve; Physics of fly fishing; Resonance in a plastic balls containing a hole; Rotational motion of a can filled with liquid; Up thrust of rotating helicopter blades; Effect of electric resistance on magnetic damping; Resistance on a multi-spherical-hulled watercraft; Magnetic field applied to a cloud chamber.*

Some classical topics such as water rocket or efficiency of turbines have been approached in an original and clever way coupled with an excellent and personal presentation. Aerodynamics or hydrodynamics was popular, however often topics were too complex both theoretically and experimentally e.g. wing tips aerodynamics. A common flaw in such cases was a lack of personal (added value) contribution. The student should not simply be an informant. Students should be wary of problematic, time consuming set-up constructions (e.g.

wind tunnel). Physics not design is the subject. Sports are popular (e.g. *Ball trajectory launched by pitching machine*) but the challenge was to focus on an accessible physics event. The quality in sport essays varied; there was clear success when the bio-mechanics was realistically circumvented (a simple and efficient model established) and relevant data collected. Good theoretical essays have been rare possibly because few students were familiar with iteration. Essays coupling theory and iteration can be impressive. A number of data-based essays did well. It is an approach worth encouraging. Disappointingly in spite of clear warnings in the Guide (physics chapter) a number of students ventured into black holes, worm holes, string theory, Bose-Einstein condensate, dark energy, time paradox etc … Such essays did poorly. Music is popular and successful if physical acoustics is involved rather than psychological acoustics or physiological acoustics. Other areas of interest: model sailing boat, damped oscillations and solar cell efficiency (too often concepts confused and key circuit theory relevant to procedure ignored). Some students applied an iPhone to detect and measure oscillations or modern probes and software to repeat Cavendish experiment.

There were examples of students involved in advanced research in university departments. In many such cases, it was difficult to assess the level of the actual understanding and real contribution of the student. Usually the best essays are accessible to other students and certainly to their supervisor and examiner. Some essays read like a PhD theses. Such an approach is not what is expected for an extended essay in physics. Some students used specialised equipment in university or industrial laboratory as “black boxes” without really demonstrating an understanding of their working.

Experimental investigation generated the most success, possibly because it was/appeared easier to respond adequately to all of the criteria. Fewer students spent too much time building apparatus or accumulating data thus lacking time to do a proper analysis. The manipulation of uncertainties and significant figures continued to improve noticeably. However there were recurrent difficulties in the determination of the uncertainty in the average value of repeated measurements as well as with the propagation of errors. Still there were good efforts seen in propagating errors, signs of improvement. The identification of ***only*** important limitation(s) as well as their impact on the results was not often completely discussed.

Personal interest can play a positive role in the selection and execution of a topic but it can also be a regrettable experience if the student blindly pursues an avenue with little relevant physics involved or problematic data collection. It requires courage and wisdom to alter direction when a preliminary investigation raises serious difficulties.

The Internet is a powerful pool. The challenge for the student was to present only the essential and *relevant* elements in a well constructed synthesis. Cut and pasted information cannot replace argument and analysis. Critical evaluation of key sources and original input were expected.

Candidate performance against each criterion

Criterion A: research question

The large majority of candidates selected a physics topic, rarely multi-disciplinary, a clear development over the years. Some topics tended to be more about chemistry than physics especially in areas common to both subjects (molecular physics/chemistry). A good number of research questions (RQ) were well and tightly defined, suitable and clearly focused but others were too broad or vague, too complex or elementary. The RQ should be naturally integrated in the introduction and not presented as an independent heading or added to the title page. The aim of the essay (RQ) was often well presented as a statement rather than a question *per se* and this is fine. At times, some unusual terms or expressions in the RQ were not defined. Generally, the RQ should be different from the title.

Criterion B: introduction

Generally candidates referred to the significance and worthiness of the topic and RQ objectively. It was unfortunate when students chose a personal approach or a lengthy historical development. A greater number of students situated the topic in its physics context but, for many, this aspect remained a weak link in the introduction. The physics context should be specifically related to the RQ as well as be directly related to the event under study by describing this event in terms of physics principles. A simple list of principles and laws is not sufficient. However, the detailed development of the theory belongs to another chapter or section of the essay. The element “how the investigation is undertaken” is required in the abstract. There is no need at all to repeat it in the introduction. The introduction is the first opportunity for the student to show knowledge and understanding of relevant physics, to demonstrate academic strength. Any statement of a hypothesis does not belong to the introduction.

Criterion C: investigation

All approaches or treatments of the topic require sources *specifically* relevant to the topic (physics theory) and actually used in the research. Web-based references are ubiquitous but there was a tendency to list many without discrimination or, when necessary, without cross-referencing. Some students consulted too narrow a range of sources considering their RQ. Sources should not be limited to the Web though it is recognized how much is available on the Web. Results were not always compared to literature values when it was a natural thing to do. It is the nature of the topic (RQ) that determines a “minimum” requirement of sources. A guideline would be that quantity does not replace quality. In some cases, a good bibliography was not taken advantage of, especially in the building up of a theory.

In a number of experimental essays, the limited amount of data did not permit a convincing analysis or the development of a valid conclusion. A general rule of thumb is that at least seven points should be on a graph but this is ***only*** indicative. On the other hand some students generated an unnecessary large amount of data because of a multiplicity of independent variables. As a consequence, they encountered difficulties presenting the data in a clear fashion and ran out time to do a proper and complete analysis centred on a proper *physics mode*l. Generally students were careful in their selection of procedure and material. Lacking at times were serious preliminaries aimed at identifying consequential procedural flaws or misuse of equipment. On the other hand, a description of all *preliminary steps*, a clear tendency in a good number of essays, should *not* be included in the essay since any research goes through preliminaries. What was done *during* the investigation to ensure that a parameter remains constant as initially indicated? A number of experiments were simply poorly designed, bound to fail or produce poor or unusable results suggesting that students were clearly not thinking *while* they were doing the practical work. The thinking should not be limited to the write-up phase. The goal of the essay should always be present.

Generally students showed an awareness of the limitations imposed by the equipment or the procedure and rarely ignored uncertainties. Quality assessment comes under criterion F. Some students confused precision of an instrument, uncertainty attached to a measured value, propagation of errors, random errors and systematic errors, range of an experimental value, difference between accepted and experimental values.

In data-based essays, the common weakness was to say little about the origin of the data (e.g. instrument used) their uncertainties or limitations. Theory was more naturally introduced.

Theoretical or survey type essays were rarer. The tendency was to take too broad and complex topics that are actually discouraged in the guide.

Overall students demonstrated satisfactory planning.

Criterion D: knowledge and understanding of the topic studied

Any topic needs a crisp theoretical summary coupled to a carefully designed RQ and study. Some topics were too challenging thus this requirement could not be fulfilled. For example, airfoils, a perennial favourite are in fact a deeply complex theoretical topic (i.e., not just write "Bernouilli says …"), but, after exploring some simplified views, some students were able to get on some meaningful experimental investigation. Too often there was a *lack of focus* on the RQ *per se* with some padding or filler of general physics to fill in space or regurgitating theory without demonstrating any personal understanding (essential part of the essay) or connection to the RQ. Some students researched little existing knowledge and, others gave a strong account of it, successfully. Interestingly, other students started from an article or existing knowledge and presented their own well done investigation. A relevant academic context was missing in many essays and occasionally the physics initially mentioned was never used. Students who explored unchartered areas requiring the development of a model or theory a bit outside of the IB curriculum found it challenging to do well. This comes back to the choice of a topic/RQ that is realistic concept wise and source wise, a topic that will permit a thinking student to contribute a personal add on value. It seems that, in the process of finding a topic/RQ, the focus was principally on the acquisition of data not on the relevant physics theory. The theory plays a key role in the analysis and evaluation as well as in the holistic judgment. An improvement was observed in a much lesser use of *hypothesis* in situations that did not call for it.

Criterion E: reasoned argument

Arguments, at times, were not based on proper reasoning. *Continuity* in the reasoning, information was not seen much in many essays. Some descriptions of graph were done without reasoning. In answering the RQ, often students left some gaps in the development of the argument. As always, many opportunities to display student analysis, critical thinking, and reflection were not on seized by relating a statement or value to a simple calculation or comparison (e.g., "what if …", or, "given …, under the limiting conditions of … an upper-bound estimate would be …", a comparable situation (e.g., "this can be related to … where we find that …"), an alternative perspective (e.g., force dynamics versus energy exchange analyses), an analogy or model (e.g., wave or particle theories of light). Such interjections would highlight the student's thinking, and that is what the EE is about. The reader should not be left wondering "Where is that coming from?" or be left alone to do the analysis of a graph e.g., "It can be clearly seen from the graph that …" . Statements were not always supported. Too often the essay digressed into areas foreign to the RQ. Consequently, a reasoned argument was replaced with added information. There were cases where a lack of organization (presentation) or communication (language) undermined the strength of the argument. In a well argued essay the parts of the essay will be related coherently and explicitly always in relation to the RQ.

With good planning and careful research, an efficient reasoned argument will develop as a natural progression through the essay. Top mark requires **close reasoning** as well as **good communication.** The quality of the analysis is assessed under the next criterion.

Criterion F: application of analytical and evaluative skills

The manipulation of significant digits improved significantly with only occasional serious abuse. Most students are aware of uncertainties and will incorporate them in data tables. The origin of uncertainties was not always explained and some estimates not correct e.g. half the smallest division taken as the uncertainty or the uncertainty attached to *both* ends of a measuring ruler ignored. Too often the uncertainty on a measured value did not match the digits of the value e.g. (2.4 ± 0.05) cm is inconsistent. Some students seem to ignore the knowledge acquired in the IA programme. Basic propagation of errors was respected, more complex cases less successfully. It is important to inform the reader how uncertainties are determined but this should ***not*** become too laborious or the main focus of the analysis. A *common sense* justification of the uncertainties in light of the experimentation performed is encouraged.

A *very common* weakness was the lack of appreciation of the uncertainty attached to an **average** value. The difference between the maximum and minimum values divided by two maximizes the uncertainty attached to the mean value and does not take full advantage of the repeated measurements (assuming a normal distribution). The standard deviation is not an uncertainty *per se*. Without going into advanced statistics, the EE student should be aware of the classical method to determine the uncertainty on an average value.

In many cases, graphical analysis was not done properly or completely. Equation of graphs, line of best fit, maximum and minimum slope to describe the relationship were missing in a good number of essays. Software removes a lot of the mechanical burden of plotting, but there is still insufficient attention paid to uncertainties. A point of real concern is that the software often offers automatic fitting and parameter estimation for various functions (usually polynomials of degree n, or sometimes exponentials) and students blindly fit to a function with no justification that is model-based (physics) or even intuition-based. This is not science. In some other cases, students accepted a software- proposed function even if the data points **clearly** showed a different trend, under the "evidence" of the correlation factor. Software should be used as a tool not as an end by itself (if not, the essay becomes purely empirical).

Error bars were often ignored when using Excel to draw line of best fit. Many graphs were *too small* (a common weakness in presentations) to show error bars so students assumed they were negligible. In this respect, many candidates placed too much dependence on Excel to produce equations *per se* instead of, *very importantly*, referring to **theoretical** equations (model) relating the variables. These equations define the proportionalities between variables, proportionalities that can be verified using a log-log graph plot to find a power relationship.

However, the analysis and evaluation of the results in **light of a physics theory** is at the core of a proper analysis, **not** the establishment of purely mathematical/empirical relationship.

Whatever is written in Excel graphs e.g. the R squared factor, must be used, justified or explained, if not better to drop it.

Rarely was an experimental value with its uncertainty compared to an accepted value from literature. Is the accepted value within the range?

Only *key* and *significant* limitation(s) or source(s) of errors should be brought up *and* their impact on the results appreciated. The clear tendency was to produce a long list of them. The reliability of secondary sources was often not brought up.

A systematic, in depth critical analysis is required. Superficiality, lack of argument or lack of reasoning seriously weakens the analysis and evaluation.

Criterion G: use of language

There is a language of science and physics. Good knowledge will enhance the language. In many cases, students clearly and *specifically* defined symbols used in equations as well as new terms not part of basic physics, however this was not always done rigorously especially in the vague identification of symbols. Generally, SI units were used though there were some unfortunate exceptions. Only the International System of units and their standards should be used. A look at IB physics exams is a good start to learn how unit symbols are utilized (multipliers, composite units). A very common weakness is a lack of proper spacing in composite units (e.g. $\mathbf{ms^{-1}}$ is not a unit of speed). Serious efforts by most students were made to use relevant and proper terminology as well as a proper style. A recurrent weakness was a lack of ***official standard*** in writing numerical values with their units and uncertainty integrated. The exponential nature of a graph was often claimed without any proof. Rigour is of the essence. Some students were careless and confused force with energy, energy with power, rates with speed or momentum with kinetic energy. In data tables, often, symbols of variables were not defined or not *precisely/specifically* defined. Units were included at the top of columns but missing for uncertainties. (Uncertainties should carry units independently of the units associated to the column variable).

It seems that more diagrams were included in essays. However this important, powerful and *highly* efficient **communication** tool remained very *seriously underused*. ***Annotated diagrams*** should be integrated with text in the body of the essay (not in the appendix) and systematically used to explain a concept, to illustrate the forces acting on an object (free body diagram), to introduce an experiment set-up, to describe an event or to represent objects (bicycles, music instrument, turbine, electric circuit...) A scientific diagram is generally **far more efficient** than photos. In 90% of the cases photos are **not satisfactory** at all and useless i.e. without any clarity added, independently of the fact that they were very rarely annotated. Diagrams can be used to more easily, more compactly and more clearly explain things. Indeed, with too many words students often manage to get mixed up, to repeat or misstate themselves. Time wise, it is better to create their own diagram rather than loose time using online software or source extracting detailed diagrams carrying unnecessary information that will require explanation. Adaptation of diagrams or graphs from a source is fine if the source is cited (*Adapted from* …). The use of diagrams should greatly help **ESL**

students as well as others. Diagrams, as data tables and graphs, should be numbered and labelled for quick reference done in the text. Physics papers or articles clearly illustrate their very useful use.

Language communication is not well served when **key** diagrams (theoretical concept, experiment set-up …) are missing or relegated to the appendix. Personal pronouns were used in a number of essays. They should be avoided.

Criterion H: conclusion

The conclusion should present a new synthesis in light of the previous discussion. Overall conclusions were satisfactory to good with a tendency to include issues not analyzed throughout the essay. Efforts were made to give a justifiable answer to the RQ though, at times, data did not really support the answer. A number of students presented sensible, well supported conclusions, including only relevant limitations *as well as* underlying their impact on the results. Some students were hesitant about reaching a definitive conclusion and never took a final stand, (understandingly in the cases where there was an insufficient amount of data). Simply stating that an initial hypothesis has been confirmed is insufficient. The inclusion of unresolved questions is not appropriate to all topics concerned. There was a clear tendency, unfortunately, to spend a good part of the conclusion on this aspect with a long list of unresolved questions often not really immediately relevant to the research undertaken.

The conclusion should be the last part of the core of the essay *after* the analysis and *after* the evaluation. If not, it can be confusing to identify exactly the conclusion reached. Ideally it is short, brief and well focused.

Criterion I: formal presentation

There is evidence that many students made special efforts in presenting their essay in a satisfactory manner with clear progress in some areas and little in others. Most performance varied between satisfactory (2) and excellent (4).

Organization of the essay: a recurrent and common weakness is the presentation of long and exhaustive ***list of equipment*** including nuts and bolts, even longer when construction is involved. This is **not** in line with a research paper and must be avoided. Instructions for the construction of piece of equipment do not belong to a physics paper. Instead a clear, complete and ***annotated*** diagram of the experiment set-up should be used and commented or, possibly, a circuit diagram. Key relevant information related to special measuring equipment (e.g. precision, calibration....) or software should be briefly given.

Another recurrent and common weakness is the ***cookbook recipe style***, step-wise presentation of each and all of the steps taken in the manipulation of the equipment and the acquisition of the data (e.g. “Step 7. Turn on the power switch”). **No** useful purpose is served by this approach. A ***very brief*** synthesis that allows the reader to reconstruct the method will suffice. Of course it can include *special* relevant elements of the procedure. Improvement in these two areas will give to the student more time to dedicate their thoughts to physics and will significantly simplify the writing of the essay.

Other aspects of poor organization of the core of the essay are regular references to the appendix or to footnotes or with statements such that “As I wrote before…” or “This issue will be looked at later on in the essay”. The organization of the essay must aim for an uninterrupted flow of the body of the essay. A ***representative sample*** of raw data and transformed data ***must*** be included in the core of the essay, similarly for graphs. The use of family curves on one set of axes would both compact data presentation and explicitly highlight differences in results and relations. Overcrowded and multicoloured graphs were often difficult to read and to interpret. Lengthy, multiple, *repetitive* raw data tables or graphs should be located in the appendix (remembering that the core of the essay must be self-contained for readers, the examiner being one of them). The examiner is ***not*** required to read the appendix. So what is there must *not* be *vital*. A typical situation, to a *much lesser* extent now, was to produce large quantity of data and graphs and run out of time to do the analysis. In such a case, the theory for experiment A is presented, then for B and C, then the procedure for A, B and C, then data of A, B, C …*very seriously* interrupting the interrupting the flow of ideas.

Graphs: axis of labelled graphs should be indentified with physics terms (not mathematical variables x and y), and show max and min slope lines and best fit, if applicable, and carry units and error bars. All information produced by Excel should be briefly defined, or explained, or described.

Formal elements:

Quotations, citations and bibliography: the situation is improving though a formal documentation style is not always used. **All and only** citations listed in the core of the essay should appear in the bibliography. Access dates for online sources were generally included. Sourced diagrams however were often unreferenced. Some references given were repetitive or of little use. Some students confused citations and footnotes. Examiners do not have to read footnotes that add an explanation to the text. Abuses of such footnotes were very, very rare. A number of students lost marks because of some *missing* formal elements. ….

Layout: formulae were *often* cut and pasted with different typefaces or fonts and using different symbols for the same variable. The essay should not look like a *scrapbook.*

Students must be made aware that their essay must follow a prescribed format in line with a *scientific paper* not in line with a typical IA (extended) lab report.

Padding, filling and, **often**, repeats were weaknesses commonly observed. It has an impact on criterion E: reasoned argument.

Criterion J: abstract

Three elements are required for the abstract. Occasionally the third element (conclusion) was missing or much too brief. Also, it is not sufficient to just write that a conclusion will be given. The second element (how investigation undertaken) was often incomplete hence vague, or totally missing. In experimental essays, essential information indicating how the experiment was performed and which measurements were made should be given. Notice that the abstract will be judged on the clarity of the presentation of the elements not on their intrinsic quality. It is sad to lose one or two marks (level 0 if one element missing). All students should score top marks here. A suggested approach could be to write one paragraph for each element. The *maximum* number of words (300) is very rarely exceeded. The RQ should be integrated in the text of the abstract. The abstract comes after the title page, before the contents page.

Criterion K: holistic judgment

On average, students reached level 2. A lack of depth of understanding because of little or weak physics theory was an important factor as well as a lack of creativity or originality. It is expected that the student will contribute a ***value added*** to our knowledge, a **personal input**, without expecting a major discovery or an entirely new piece of research. The report of the supervisor can be highly useful to the examiner since this report is centred on criterion K. It should illuminate the context in which the work was carried out. Examiners do take it into consideration. No doubt, determination and enthusiasm were present but creativity tended to be replaced by searching on the internet. Several creative, ingenious and interesting topics were presented.

Recommendations for the supervision of future candidates

Supervisors should:

- Ensure students are **familiar** with all criteria and their interpretation. Through an automatic application of the requirements of "technical" criteria (A, B, H, I and J) students should score at least 10 marks by just following the correct procedure. Overall, with a modest investment of time and talent, a student must be able to achieve at least a score of 19. The EE guide is divided in two sections: *the physics specific chapter* should not to be ignored.

- Make available accessible and relevant physics papers or physics articles taken from physics journals or magazines. This is an effective way for the student to see how to plan a ***formal piece of scholarship***. The student will realize quickly how focused and well organized the development is and will appreciate the style and the language of a scientific paper including the use of equations, diagrams, data tables and graphs. The difference in presentation between an extended essay and a lab report submitted for IA will become evident.

- Give some **examples** of topics /RQ (the majority of students have little or no clue as to how to phrase a research question). Specifically refer to some briefs articles or papers from magazines e.g. *The Physics Teacher* or journals, covering different areas of physics.

- Introduce students to the elements of **information literacy** so that they become better information searchers, analysts and evaluators. This is vital in a world not of information silos and paucity but, rather, information overload. As a corollary, the fine art of note taking needs to be taught as a skill.

- Play a **key** role assisting students choosing a **topic** and a research question relevant to physics and appropriate to their intellectual skills and abilities. Obviously this is of critical and vital importance. For most students, this is the first scientific essay they will research and write about. Guidance is a *sine qua non* condition for a majority of students. The ambition and enthusiasm of the student might need to be modulated or tempered with wisdom. Extra care should be shown before choosing a completely theoretical topic. Purely empirical essays must be avoided at all costs. The choice of the topic and RQ should carry a **touch of originality, creativity, initiative** … The essay must carry a personal touch, an *added value* that can take different forms. Hopefully the student is eager to get an answer to her/his research question!

- Intervene rapidly to avoid a **disastrous error** be it theoretical, experimental or numerical. For example a calculation of changes in kinetic energy could be mistakenly calculated as $(v_2 - v_1)^2$ rather than $v_2^2 - v_1^2$ The very negative impact of such an error on the analysis and evaluation can easily be imagined. This type of error should not be corrected for the student by the supervisor but it is quite permissible and expected to suggest the student looks at the calculation again. A Socratic approach respects the student's ownership of the investigation.

- Follow the progress of the student closely; focus on the RQ and bring **support** and encouragement.

- Encourage **preliminary** work, **practice** for experimental essay (preliminaries should *not* be included in the essay).

- Guide student towards proper sources dealing with **uncertainties**, errors, propagation of errors, and uncertainty in the mean…essentials to be considered here, no need to go deep into sophisticated statistics.

- Assist with the **presentation** of the essay e.g. clear references and citations (footnotes in core of essay), effective annotated diagrams, *specific t*able of contents, organisation of the essay which should **not** be an IA lab report. There should be a strict logical order and symbols must be defined and coherent. It is recommended that students consult the writing guidelines in **International Organization for Standardization (ISO)** and **NIST Guide to the SI.**

  Only SI units must be used.

- Make sure students have chosen an *official documentation style*. .

- Remind students that very good essays **do not require** a hypothesis or an appendix; the maximum numbers of pages are intended as actual maximum not a measure of success. (Examiners do not have to read the appendix). Also, quality and in-depth text is **superior** to quantity and superficiality.

- Ensure the **authenticity** of the student's work. Ideas, adaptations should be credited also.

- Administrative issues: when photocopying, make sure that the official final version of the EE is complete. Each year we have essays e.g. with 2 pages no 7 and none of page 8, or with an abstract missing even though the table of contents clearly refers to it. The final version should not carry any annotations from the supervisor.

- Supervisors are *strongly* encouraged to write a few comments on the cover sheet about the student's motivation, perseverance, self-reliance, intellectual initiative, insight and depth of understanding, originality and creativity, **personal input or added value**.