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Developing accelerometer based running speed gauges

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Abstract
This research aims to generalize speed measuring instrument based on *accelerometer* which is proper to measure speed of 100 m run. This study is research and development by adopting the steps: (1) introduction study, (2) first product design, (3) validation and revision design (step I), (4) validation and revision design (step II), (5) effectiveness test, (6) final production. The subject is the athlete of student activity units of Yogyakarta State University (YSU) amount of 9 athlete. The instrument is using questionnaire for athletics expert, media expert, and respondent. The technique of analyzing data is descriptive qualitative and quantitative by using significance level 5%. The result of this research is speed measuring instrument based on accelerometer, which is developed effectively to measure the speed and run acceleration 100 meter and then proper to use as alternative instrument to measure speed of 100 m run. The instrument output is data of time, speed, and acceleration in graphics.

Keywords: Speed, Accelerometer, 100 Meter Run

Introduction
The progress of Sciene and Technology is rapidly developed. That case is notified by new inovations in discipline science. Sport is applied sciences which is influenced by the technology to support the sport activities. The Law of Indonesia Number 3 Year 2005 about National sportmanship system (*UU-SKN*: 2), section 1, subsection 1 explain that "sportmanship is all aspect linking to sport which needs admission, education, training, coaching, developing, and monitoring". Then, system of sportmanship contains three scope, namely sport education, recreation, achievement. Sport achievement is physically activity to reach the maximal achievement target. Sport achievement needs totally support from certain discipline sciene to reach best achievement. The coach uses technology in sport achievement to assist and to maximalize training process.

The branch sport of athletic is body activity that consists of basic dynamic and harmonic movement, namely walk, jump, run, throw (Edy Purnomo, 2007:1). There are 44 official event which is matched in multievent such as PON, Sea Games dan Olympiad. Each category has different characteristic. In run category, there are many factor influenced in achievement, as speed, power, coordination, flexibility, and endurance. Speed is divide result between run distance and time achieve. Speed is necessary for athletic runner. The coach must know the speed and time record in every athlete in order to be able to evaluate and to correct the strength and weaknesses. Speed control become an important thing in running, because an athlete can set the speed of running. The observation of running in speed and velocity is used stopwatch with variety accuration. It is depended on the stopwatch user. The operational of stopwatch is no reliable because of tiredness, carefulness, adoritness factors.

Besides that, stopwatch user is just measuring average speed and not velocity. Speed and velocity moment on running are necessary thing to know, in order to catch the characteristic of the athlete. The fact on the field which is occured, the coach and atheletete are difficult to control and to know the time and distance in training. The other problem in training relate to the record-keeping of data collection in the field with minimalize instrument. By using technology as stopwatch, the coach can analyze the time speed with taking the run record athlete of short, middle, long distance run. The data result must be converted to become the prcise data appropriate to the coach expectation.

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Another technology is camera which is following the runner in competition. This technology is very expensive creation, because it needs the railway camera along the circuit, motor drive, and chassis motor drive to follow the athlete movement during competition.

The camera must have high resolution to detect every movement of athlete during run. Therefore, the instrument which is able to monitor the accuracy running, reliable, and thrifty very needed. A sensor can be used to monitor physic phenomena such as, speed, velocity, force, pressure or stream in electric scale. The electric scale is comparable with the velocity. The first parameter physic score can be re-counted refers to the characteristic of an amplitude electrical signal, frequency or electrical pulse width. The electrical signals can then be analyzed in real time and for later analysis purposes.

The sensor size is very important, the smaller sensor is easier applied to many necessary. Therefore, the need of sensor covers the easy use, sensitivity level, and price. This application is accelerometer which can measure the velocity and deceleration an object on one direction or more. The small size of accelerometer make it economical. By the velocity data of accelerometer is probably stake out the monitoring system of running activity with low budget, accurate, and reliable. Accelerometer is a sensor which is detecting the alteration movement speed (velocity or deceleration) on one direction or more in electric signal. The sensor must be patched on the measuring area. Accelerometer sensor is many used, for example, From automotive health, information technology to rocket development satellites.On the previous development the speed measuring instrument is occured problem in working, as lost signal, signal out of read. It is caused by the limitation range of radio signal sender that exist on the tools. Then, the analysis tools is big enough and out of the box antene that make shake-up on running. Therefore, development is needed to refine and reduce the weaknesses that occur when the analysis process runs. Future development is expected to be better than ever by minimizing the shape of the tool, improving the often lost signal, eliminating the antenna to decrease the shock. In the future this tool is not only for athletic sports but for all sports that require movement speed, acceleration movement, and motion deceleration.

Materials and Method
This study is about Research and Development. The research method and development include in category "need to do", that is a research for helping a work. According to Borg & Gall (2007, p.569) the research of R & D is "Educational Research and Development (R&D) is a process used to develop and validate products.In contrast, the goal of educational research is not to develop products, but rather to discover new knowledge (through basic research)". This research aims to change the manual system of speed measuring instrument with less accuracy becoming speed measuring instrument based on accelerometer, which is good and easy use in operational for the athlete and the coach. The research procedure and development use the simplified stage of Borg and Gall (2007, p.775-776). The research and development design design is became more simple involving the first stages: (1) Introduction Study, (2) First Product Design, (3) Design Validation and Revision (Stage I), (4) Design Validation and Revision (Stage II), (5) Effectiveness Test, (6) Final Product.

This research subject is athlete 100 m run of Yogyakarta State University which is amount of 9 athlete. The test is divided into small and big scale though expert vaidation, that is athletic expert and two media expert.To generalize the quality of development model, the instrument is needed to search and to collect the data in this research. The instrument is questionnaire. The instrument is given for: (1) athletic expert, (2) media expert, (3) and for athletic athlete to score the respon after use the development instrument.The technique of analyzing data use descriptive, that is described the result product design after implemented in form of finished product and testing product. According to B. Syarifudin (2010: 112), the way to change score/ point into precentage is using the formula, as follows:

$$\% = \frac{\Sigma n}{\Sigma Max} \times 100$$

Information
% : Precentage
Σn : Score X Count
ΣMax : Ideal Maximum Score

After the data collected, the score is compared with the highest total score to get precentage. The product is proper, if it fullfil the requirements more than 70%. Those precentage are estimated qualitative condition (Suharsimi Arikunto: 1998, p.246), if those barrier in precentage between:
a. < 100% means excellent/proper
b. 61% - 80% means good/proper
c. 41% - 60% means sufficient/proper
d. 21<40% means bad/proper
e. > 20% means very bad/proper

The research result is tested using *t-test* with significance score to compare the differences between two average score with *error* standart from the difference of two average sample.

Result
The researcher use concise stages, as follows: (a) Introduction Study, (b) The Development First Product (Stage I), (c) The Development First Product (Stage II), (d) Product Evaluation, (e) Product Revision, (f) effectivity test, and (g) last product. Each stage will explain, as follows:

Introduction Study
Based on the research procedure which is adapted from Borg and Gall, this research is started from the collecting data and information analysis into creating product. The development product in this research is the speed measuring instrument based on *accelerometer*. The expert will be validating the stacked first product design to determine the product feasibility before tested out on the field.The created model is the speed measuring instrument which can detect acceleration and deceleration and prove the accuracy data. The accuracy data is got by the measuring using *stopwatch* with the measuring instrument that will be made. The writer is designed by the observation, interview, and collecting the informations, where *Accelerometer* is technology seldom implemented in development speed run instrument.

The Development Result of First Product (Stage 1)
The first product is the speed measuring instrument which can detect acceleration and deceleration. It needs the expert to validate this instrument before test. The result score of athletic expert and media expert toward first draft, as follows:

The Assessment Athletic Expert Stage 1
The result of validation product from athletic expert toward to first draft can be seen on table 1, as follows:

Table 1: The Data Result Assessment of Athletic Expert Stage I

Expert	Aspect	%	Category
1	Instrument	84,62	Excellent
	Function	100	Excellent
	Manual Book	80	Good
	Total	84,21	Excellent
2	Instrument	76,92	Good
	Function	100	Excellent
	Manual Book	60	Excellent
	Total	73,68	Good

Based on Table 1 above can be explain, as follows:
a. The assessment of expert 1 toward to first draft overally show that the developed product is in excellent category, with precentage as 84,21%
1) Instrument aspect is in excellent category, with precentage as 84,62%
2) Function aspect is in excellent category, with precentage as 100%
3) Manual book function is in good category, with precentage as 80%
b. The assessment of expert 2 toward to first draft overally show that the developed product is in excellent category, with precentage as 73,68%
1) Instrument aspect is in good category, with precentage as 76,92%
2) Function aspect is in vey good category, with precentage as 100%
3) Manual book function is in sufficient category, with precentage as 60%

The suggestion and correction from both of the athletic expert 1 and 2 on stage I can be seen clearly in the table 2 below.

Table 2: The Suggestion of the Athletic Expert 1 and 2 on Revision Stage I

Expert	Suggestion
Expert 1	1. Minimalize form 2. Calibration is necessary to others 3. Wifi or wireless is better
Expert 2	1. Elastic and strong strap are needed to decrease shaking 2. Use contrast colour bag with on/of button 3. Made of how long the distance acceeration 4. Unreadable stable 5. The display unread well 6. Minimalized the size 7. Add the distance graphic

Based on the suggestion and correction from the expert validation stage, then the researcher revises toward to first product before the next test, namely product test (Stage II).

The Assessment Media Expert Stage I
Table 3 explain the result validation product by media expert towards to first draft, as follows:

Table 3: The Data Result Assessment of Media Expert Stage I

Expert	Aspect	%	Category
1	Instrument	81,25	Excellent
	Function	66,67	Good
	Manual Book	60	Sufficient
	Total	75	Good
2	Instrument	81,25	Excellent
	Function	66,67	Good
	Manual Book	80	Good
	Total	73,68	Good

Based on the table 3 above can be explain,as follows:
a. The assessment of expert 1 toward to first draft overally show that the developed product is in good category, with precentage as 75%
1) Instrument aspect is in excellent category, with precentage as 81,25%
2) Function aspect is in good category, with precentage as 66,67%
3) Manual book function is in sufficient category, with precentage as 60%
b. The assessment of expert 2 toward to first draft overally show that the developed product is in excellent category, with precentage as 73,68%
1) Instrument aspect is in excellent category, with precentage as 81,25%
2) Function aspect is in sufficient category, with precentage as 66,67%
3) Manual book function is in good category, with precentage as 80%

The suggestion and correction from both of the mediaexpert 1 and 2 on stage I can be seen clearly in the table 4 below.

Table 4: The Suggestion of the Media Expert 1 and 2 on Revision Stage

Ahli	Suggestion
Ahli 1	1. Easy connection between instrument and computer 2. Wifi usage is more simple 3. Completed and needed result information table neatly
Ahli 2	1. The button symbol should use contrast colour to make it clear 2. The start button is changed to be green colour 3. Add the identity in the software 4. Created with bright colour and increase the font size 5. The cover is added software image and USB cable to make easy understand 6. The foreign terms are italicized and used bold for certain things

Based on the suggestion and correction from the expert validation stage, then the researcher revises toward to first product before the next test, namely product test (Stage II). The researcher examines the suggestions from the expert to create proper product. The suggestions is very helpful to improve the draft or the product that will be produced later.

The Result of Product Test (Stage II)
After validation stage to material expert and media expert to first draft (stage 1) and have revised according to suggestion, then the researcher tested toward product, which is developed. The next stages can be seen as follow:

Functional Test

Table 5: The Result of Testing Instrument Functionally

Test	Measurer Instrument *Accelerometer*		*Software* Viewer	
	Censor *accelerometer*	Data Sender	Data Receiver	Data Viewer
1	Success	Success	Success	Success
2	Success	Success	Success	Success
3	Success	Success	Success	Success
4	Success	Success	Success	Success
5	Success	Success	Success	Success

Error tolerance can be measured according to the measuring of deviation:

$$Deviation = \frac{the\ number\ of\ deviation}{the\ number\ of\ testing} \times 100\ \%$$
$$= \frac{0}{10} \times 100\ \% = 0 \times 100\ \% = 0\ \% \qquad (2)$$

According to the table and measuring above, it has the result of tolerance 0%. It gets from 5 times testing with operate the instrument and ensure the hardware and software work well.

The Assessment of Athletic Expert Stage II
The result of validation product by the athletic expert toward first draft clearly can be seen on table 6 below:

Table 6: Data Result of Athletic Expert Stage II

Expert	Aspect	%	Category
1	Instrument	92,31	Excellent
	Function	100	Excellent
	Manual Book	100	Excellent
	Total	94,74	Excellent
2	Instrument	100	Excellent
	Function	100	Excellent
	Manual Book	80	Good
	Total	94,74	Excellent

According to the Table 6 above, it can be explained as follows:
a. Assessment of expert 1 toward first draft totally shows that product which is developed in the excellent category with percentage 94, 74%.
1) Instrument aspect in excellent category with percentage 92, 31%.
2) Function aspect in excellent category with percentage 100%.
3) Manual book aspect in excellent category with percentage 100%.
b. Assessment of expert 2 toward first draft totality shows that product which is developed in good category with percentage 94, 74%.
1) Instrument aspect in good category with percentage 100%.
2) Function instrument in excellent aspect with percentage 100%.
3) Manual book aspect in good category with percentage 80%.

The following will explain suggestion and revision from athletic expert 2 and athletic expert 2 in stage II, it can be seen clearly on the table 7 as follows:

Table 7: Suggestion from Athletic Expert 1 and 2 in Revision Stage II

Experts	Suggestion
Expert 1	-
Expert 2	Colorful belt make it more impressive,

Based on suggestion and revision from the expert validation stage, then the research must be revised. The researcher is reviewing the suggestions from the experts to make the product perfectly. The suggestions from the experts are very helpful for the researcher to fix the product that will be released. According to the product stage test 1 shows that the product which is developed already good, so it does not need revision.

Assessment of Media Expert Stage II
The result of validation product by the experts toward first draft clearly can be seen on table 7 as follows:

Table 8: The Data Result Assessment of Media Expert Stage II

Experts	Aspect	%	Category
1	Instrument	93,75	Excellent
	Function	100	Excellent
	Manual Book	80	Excellent
	Total	91,67	Excellent
2	Instrument	93,75	Excellent
	Function	100	Excellent
	Manual Book	100	Excellent
	Total	95,83	Excellent

According to the Table 8 above, it can be explained as follows:
a. Assessment of expert 1 on the stage II totally shows that product which is developed in excellent category with percentage 91, 67%.
1) Instrument aspect in excellent category with percentage 93, 75%.
2) Function aspect in excellent category with percentage 100%.
3) Manual book aspect in good category with percentage 80%.
b. Assessment of expert 2 totally shows that product which is developed in excellent category with percentage 95, 83%.
1) Instrument aspect in good category with percentage 93, 75%.
2) Function aspect in excellent category with percentage 100%.
3) Manual book aspect in excellent category with percentage 100%.

The following will explain suggestion and revision from the media expert1 and media expert 2 in stage II, It can bee seen clearly on the table 9 as follows:

Table 9: Suggestions from Media Expert 1 and 2 in Revision Stage II

Experts	Suggestion
Expert 1	-
Expert 2	1. It can be given special color instrument appropriate with software 2. The word "*save file*" can be added "*save file as...*" can be bilingual Indonesia-Inggris 3. Size of manual book can be minimized such as the other electronic products.

Based on the suggestion and revision from the expert validation stage, then the researcher does revision. The researcher is reviewing the suggestions from the experts to make the product perfectly. The suggestions from the experts are very helpful the researcher to fix the product that will be released. According to the product test stage II shows that the product which is developed already good, so it does not need revision.

The Result of Product Evaluation by Respondent
After the researcher gets validation stage 1 and stage 2. The next step is validation and spread the product evaluation form to respondent. In this section, 9 athlete of student activity units of Yogyakarta State University (YSU). The result can be seen as follows:

Table 10: Data Evaluation Result by Respondent

Aspect	%	Category
Instrument	72	Good
Function	72,78	Good
Manual Book	75,78	Good
Total	74,15	Good

Based on the table 10 above, it can be explained as follows:
a. Instrument aspect in good category with percentage 72%
b. Function aspect in good category with percentage 72, 78%.
c. Manual book in good category with percentage 75, 78%.
Assessment of all respondents show that the product which is developed in good category with percentage 74, 15%. The following will explain suggestions and revisions from the respondents, it can be seen clearly on table 11 as follows:

Table 11: Suggestion from the Respondent after Use the Instrument

No	Suggestion
1	Need more refinement in order connectivity to software can be faster, so it save time, instrument is very helpful to know the time in 10 meter.
2	The convenience of this instrument is still quite enough, sometime the censor instrument respond less the button when it pulls then the runner should rerun.
3	Instrument is hard to understand by the runner when it used.
4	Instrument operation is simply.
5	Picture in the guide book is clarified.

Effectiveness Test
Final product that is created include speed measurer instrument based on accelerometer, it can detect acceleration and deceleration. The next step is effectiveness test that is measuring the run time distance 100 meter from athlete and comparing the time measure and stopwatch. Effectiveness test is used to compare the data instrument and stopwatch, which is using t test. The summary of analysis result t test of run tine distance 100 meter from athlete and time measuring from instrument and stopwatch can be seen as follows:

Table 12: t Test of the Result Instrument and Stopwatch

Average	t-test for Equality of means			
	t_{ht}	t_{tb}	Sig,	Quarrel
Stopwatch 16.4222	0,549	2,120	0,787	0,2889
Instrument 16.7111				

By the table t-test above, it can be seen that t count 0,549 and t table (df =16) = 2,120, significance value p 0,787. Because t count 0,549 < t table = 2,120 and sig. 0,787 > 0.05, it means no differences between that is measured by instrument and that is measured by stopwatch. The average result measuring from instrument measuring is 16, 7111 second and measuring by using stopwatch is 16, 4222 second, the quarrel is 0, 2889 second. The quarrel shows small differentiation between instrument measuring and stopwatch measuring. Based on the data analysis above, it is known the level of its differences, so the instrument can be said ready to use in run speed analysis.

Final Product
Revision is done after the product ''The Development of Speed Measuring Instrument Based on Accelerometer' is given assessment, suggestion, and critic toward the quality of the product which has been used by respondents, then it will be used as guideline of final revision.

Discussion
Product, which is developed, is proper to use as speed measuring instrument based accelerometer that can detect the speed, acceleration, and declaration. Product, which is developed in this study, has been tested in small scale and big scale. Analysis of the data result include assessment from expert, practitioner/functionary, and experiment subject, speed measuring instrument based accelerometer can detect acceleration and deceleration is proper to use. The analysis result can explained as follows:

1. The Result Development of Stage 1
In the development stage 1, product is validated by expert include athletic expert and media expert, the results can be seen as follows:
a. The aassessment of Athletic Expert Stage 1
1) The aassessment of expert 1 toward first draft totally shows that product which is developed in excellent category with percentage 84,21%.
2) The aassessment of expert 2 toward first draft totally shows that product which is developed in good category with percentage 73,68%.
b. The aassessment of Media Expert Stage 1
1) The aassessment of expert 1 in stage 1 totally shows that product which is used in good category with percentage 75%.
2) The aassessment of expert 2 in stage 1 totally shows that product which is used in good category with percentage 73,68%.

2. The Result Development of Stage II
In the development of stage II, product is validated by expert include athletic expert and media expert, the results can be seen as follows:
a. Functional Test
According to table and assessment above, it got the tolerance result of 0%. That is from 5 times instrument operation and decides the hardware and software function well.
b. The aassessment of Athletic Expert Stage II
1) Assessment of expert 1 toward first draft totally shows that product which is developed in excellent category with percentage 94, 74%.
2) Assessment of expert 2 toward first draft totally shows that product which is developed in good category with percentage 94, 74%.
c. The aassessment of Media Expert Stage II

1) The aassessment of expert 1 in stage II totally shows that product which is developed in excellent category with percentage 91,67%.
2) The asassessment of expert 2 in stage II totally shows that product which is developed in excellent category with percentage 95,83%.

3. Effectiveness Test

After the final product is released, it called speed measuring based accelerometer, which can detect acceleration and deceleration. Next step is effectiveness test, by measuring the run time distance 100 meter from athlete and compare with time measuring of stopwatch. Before experiment subject (9 athlete UKM athletic UNY). Based on the analysis result shows that there is no difference between instrument measuring and stopwatch measuring. The average result measuring which is got from instrument measuring of 16,4222 second and stopwatch measuring of 16,7111 second, and quarrels between the two of them 0,28889 second. The quarrel shows the small differentiation between instrument measuring and stopwatch measuring. According to Peter M. McGinnisn (2005: 364), states that tolerance time between instrument and handtime have average difference 0, 23 second. Based on his statement, it shows that the average quarrel between stopwatch and instrument still in the tolerance condition. According to data analysis above, that is known the level difference, then the instrument can be said that ready to use in run speed analysis.

Conclusion

Based on the development result, it can be concluded that: (1) It have been developed ''The Development of Speed Measuring Instrument Based on Accelerometer', with the steps of development include (a) Introduction Study, (b) First Product Design, (c) Validation and Design Revision (Stage I), (d) Validation and Design Revision (Stage II), (e) Effectiveness Test, (f) Massive Product. (2) Product, which is developed effectively to measure the speed and run acceleration 100 meter.

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